

# BULLETIN

OF THE

# INTERNATIONAL RAILWAY CONGRESS

## ASSOCIATION

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## REPORT No. 5

(America)

ON THE QUESTION OF ECONOMICAL TRACTION METHODS FOR USE IN  
PARTICULAR CASES (SUBJECT XII FOR DISCUSSION AT THE ELEVENTH  
SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIA-  
TION) <sup>(1)</sup>,

By H. B. VOORHEES,

Vice-President, Baltimore and Ohio Railroad,

and GEO. H. EMERSON,

Chief of Motive Power, Baltimore and Ohio Railroad.

Exhibits 1 to 35, pp. 779 to 861.

## SYNOPSIS.

**Question XII. — Economical traction methods for use in particular cases, as per example :**

*a)* Organization of train services on the minor lines of the large systems carrying little traffic, and of little used trains on the more important lines of these systems.

*b)* Use of special tractors for shunt-

ing in smaller yards and for certain work in large yards.

Questionnaire on Question XII as included in this report was submitted to twenty-three railroads in the United States and Canada and the following made reply, details of which are shown further on :

Baltimore & Ohio Railroad;

Chesapeake & Ohio Railroad;

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<sup>(1)</sup> This question runs as follows : " *Economical traction methods for use in particular cases, as for example :*

*A)* Organisation of train services on the minor lines of the large systems carrying little traffic, and of little used trains on the more important lines of these systems.

*B)* Use of special tractors for shunting in smaller yards and for certain work in large yards ".

Richmond, Fredericksburg and Potomac Railroad;  
Illinois Central Railroad;  
Philadelphia & Reading Railroad;  
Central of Georgia Railroad;  
Louisville & Nashville Railroad;  
Ulster & Delaware Railroad;  
New York Central Railroad;  
Pennsylvania Railroad.

When questionnaires were issued and up to the present time, the question of motor rail car transportation was very much in the state of flux and is still in the experimental stage, and the limited number of replies received is occasioned through the lack of sufficient experience on the part of the railroads to enable them to give any authentic data, therefore, the hesitancy of the railroads in replying.

The basis of the whole subject is that of economic operation and in order to determine this, a certain period of time is an important factor. The attitude of the public must be gauged and this can only be done by actual installation and operation of this new method of transportation and this means development of new types of equipment to meet and fulfill the requirements. It must be considered that transportation is to be furnished to sparsely settled localities, then again in highly concentrated areas of population, the character of the country through which the trains are operated, namely level, mountainous and undulating country, where it is partially level and mountainous, long runs on level lines and shorter runs in the more undulated and hilly country, and further complicated by the volume handled under the above conditions; for instance, in certain localities a 60-horsepower gas

rail motor car can handle the business offered, which is the most economical and simple form of motor car propulsion; then we have to step up to the gas- or oil-electric cars ranging in horsepower from 150 to 250, 300, 600 and 750 and then the oil-electric locomotive for main line service we enter the field of 1 000 to 1 350 horsepower.

The steam engine rail motor car is being given some consideration because of its flexibility in the rate of speed and horsepower. The application of fuel oil and distillate to the operation of the engine in the motor rail car is receiving the serious attention of the designers and developers and a most desirable detail is the perfection of an adequate mechanical variable speed drive to deliver the power from the engine without any other medium directly to the driving wheels.

The question of the operation of the rail motor cars on the steam operated lines where they interlap in their runs on the less frequented lines, occasions experience to determine as to the liability of interference. The more densely populated Continental Countries present a more complex phase of operation in handling passenger and baggage at and between stations than does the service in the Countries reporting, hence the traffic conditions in this country do not match with those of other Countries and replies to some of the questions cannot be given.

We are giving below a comparative statement showing the number of passenger, freight and mixed trains, daily operated by the Baltimore & Ohio over districts where rail motor cars are operated, which gives an idea of the proportion of each, handled in their respective territories.

Statement showing number of trains run daily over districts where rail motor cars are operated.

	Motor.	Passenger.	Freight.	Mixed.	Total.	Miles.
Baltimore & Washington . . .	4	53	15	...	72	38.3
Hagerstown, Frederick & Stras- burg Junction . . . . .	13	6	15	1	35	103.0
Harrisonburg & Lexington . .	4	...	4	...	8	62.0
Hancock & Berkeley Springs . .	6	...	4	...	10	6.0
Green Spring & Petersburg . . .	4	...	4	4	12	54.0
M. & K. Jet. & Morgantown . .	4	...	9	...	13	47.8
Charleston, Gassaway & Sutton	6	4	18	2	30	93.8
Bridgeport & Holloway . . . .	2	4	16	...	22	31.0
Parkersburg & Zanesville . . .	2	2	4	...	8	88.3
Painésville & Haselton . . . .	2	...	7	...	9	54.7
Parkersburg & Portsmouth . . .	2	10	29	...	31	128.0
Dayton & Chillicothe . . . . .	2	...	7	2	11	80.1
Flora to Beardstown . . . . .	6	...	7	...	15	154.1
Flora to Shawneetown . . . . .	4	...	7	...	...	74.0
Indianapolis to Decatur . . . .	2	2	9	...	13	153.7

These rail motor cars are operated through various characters of country and the exhibits (Nos 25 to 34) cover maps and profiles of the different divisions and will furnish a clearer idea of the country traversed. Because of the limited size of the profiles, the curvatures are omitted.

We are giving below information as to the individual runs, the divisions over which the motor cars operate, the grades and curvatures and the percentage of the relation of the curvature to the tangent. It will be noted in some instances the runs will be covered by more than one exhibit.

*Baltimore to Washington.* — This is the Baltimore Division and extends from Camden station, Baltimore City, Maryland, to Washington, District of Columbia, via Relay. Camden Station to Relay is shown on the main line profile, exhibit 25, and from Relay to Washington on the Washington Branch profile, ex-

hibit 25. The distance between Baltimore and Washington is 38.3 miles. There are four trains per day. About two miles from the station for a distance of 1 1/2 miles, a grade of 0.8 % is encountered; after this it is relatively level to Relay. About half a mile beyond Relay is again encountered a 0.38 % grade for a distance of 5 miles, then relatively level for about 8 miles when there is a down grade for a distance of 6 miles, of 0.38 %; this grade must be traversed on the return trip. Then the line runs through a relatively level country for some distance and encounters a grade going into Washington varying from 0.38 % to 0.5 % for a distance of 2 miles. The curvature encountered on this run is from 1 degree to ten degrees, mostly 2, 4, and 6°. About 30 % of the run is curvature.

The following three runs cover 13 trains.

1. — Brunswick, Point of Rocks (Was-

hington Junction) on the Baltimore Division and shown on main line profile, exhibit 25. In this run, very heavy traffic conditions are met with, both passenger and freight, over the main line from Brunswick to Point of Rocks (Washington Junction), the passenger traffic being diverted at Washington Junction to Washington City and the freight traffic diverted at Point of Rocks (Washington Junction) to Frederick Junction over the old main line through Mt. Airy on to Baltimore, Md.

This is practically a level country from Brunswick to Point of Rocks (Washington Junction) and from this point to Frederick Junction are encountered grades in either direction from 0.3 % to 0.58 % and from Brunswick to Frederick Junction about 1.5 %. This division covers a distance of about 21 miles and 40 % of same is curvature.

2. — Brunswick Weverton to Hagerstown on the Baltimore Division, a distance of 26 miles shown on profile of Washington County Branch, exhibit 25. Between Brunswick and Weverton is again encountered heavy traffic on the main line in both passenger and freight trains. Brunswick to Weverton is a level grade, between Weverton and Hagerstown; the line starts from Weverton immediately on a 1.7 % grade for a distance of over a mile and continues to climb for 7 miles mostly a grade of 1.5 % encountering curvature to the extent of more than 5° and as high as 10° and from that point for a distance of about 5 miles, it traverses a declining grade of the same per cent and same degree of curvature and from there to Hagerstown an undulated country with a general rise of 0.5 % to about 1 % for a short distance. About 45 % of this division is curvature with an average of about 4°.

3. — Brunswick, Weverton, Harpers Ferry to Strasburg, Baltimore Division, as shown on main line profile exhibit 25 and Strasburg Sub-Division profile, exhibit 26. Here again there is a heavy main line passenger and freight service from Brunswick to Harpers Ferry.

From Brunswick to Weverton and Harpers Ferry is a river grade. From Harpers Ferry to Strasburg, no particular heavy grades are encountered. About 60 % of the line is curvature wherein the highest is 5° and 13" with a general run from 2° to 4°.

*Harrisburg to Lexington.* — This is on the Shennandoah Sub-Division and covers a distance of 62 miles, having 4 trains per day, being a little used line from Harpers Ferry South. This is practically a river grade except towards the south end where for a short distance 1.4 % declining grade is encountered. About 60 % of this division is curvature, ranging from 2° to 4°.

*Hancock to Berkeley Springs.* — On the Cumberland Division, shown on exhibit 27, covering a distance of 6 miles with 6 trains per day. This is a gradual up hill grade of about 0.5 % and for a short distance of a mile 1.1 %. About 55 % of this division is curvature with highest degree of curvature 19° and 30' and ranging from 17° to 6°.

*Green Spring to Petersburg.* — Cumberland Division. — There are 4 trains per day over this division covering a distance of 54 miles. The profile is shown on the South Branch, exhibit 27. This is mostly a river line; six miles south from Green Spring is encountered a considerable rise, varying from 0.5 % up to 1.6 % and in the opposite direction this hill shows the same percentage of grade and curvature. About 60 % of

this line is curvature and ranges from 10 down to 1 degree.

*M. & K. and Morgantown.* — Cumberland Division. — This run extends 47 miles and 4 trains per day operate over same. It is shown on Cumberland Division map, exhibit 27. For 14 miles out of Rowlsburg there is a slightly declining river grade after which comes an up hill grade of 11 miles running from 1.8 % to 2.2 %. On the opposite side of the mountain there is a similar down grade in the center of which for a distance of 6 miles come declining grades from 0.3 % to 1 %. About 75 % of this line is curvature, the maximum being 11° and 30' and averaging from 8° to 9°.

*Charleston, Gassaway & Sutton.* — This is on the Charleston Division as shown on exhibit 34, a distance of 93.8 miles having 6 trains a day. This traverses a level country from Charleston to Gassaway; about 75 % of the distance is curvature the maximum being 15° and 30'. A large percentage of the grades range 5° to 8° and the remainder from 2° to 5°.

*Bridgeport to Holloway.* — On the Wheeling Division, shown on exhibit 28, a distance of 31 miles with 2 trains per day. The profile is shown on the C.L.W. Branch of exhibit 28.

From Bridgeport for 75 % of the distance there is a gradual rise in the grade from 0.37 % to 0.49 % where the line drops down a hill with 1.17 % grade. About 65 % of the division is curvature with a maximum of 8°, but generally running from 3° to 5°.

*Zanesville to Parkersburg.* — On the Newark Division, exhibit 29 covering a distance of 88.3 miles with 2 trains per day. On this run is encountered heavy

freight traffic. This is a relatively level river grade encountering in a few instances for a short distance rises of 1 %. About 65 % of the line is curvature averaging 2, 3, 4, 5 and some 8 degrees.

*Painesville to Haselton.* — On the New Castle Division for a distance of 34.7 miles, with 2 trains daily. Shown on exhibit 31. The profile from Painesville to De Forrest Junction in on the Lake Branch and De Forrest Junction to Haselton is on the old main line. We have on this line south from Painesville about 8 miles of 1 to 1.48 % grades and for four miles in the opposite direction a 1 % grade. This is a level division and there is about 25 % of curvature on the line the maximum being 8° and the major portion running from 3° to 5°.

*Parkersburg to Portsmouth.* — On the Ohio Division, a distance of about 125 miles having 2 trains per day. The profile is shown on the main line from Parkersburg to Hamden, exhibit 30, where it traverses a busy freight and passenger line and from Hamden to Portsmouth, a little frequented line, is shown on the Portsmouth Branch profile. This is relatively level road from Parkersburg to Hamden, about 30 % being curvature ranging from 1° to 5°. Hamden to Portsmouth is an undulated line with a stretch of relatively level country encountering throughout the division grades from 0.5 % to 1.5 %. About 25 % of the division is curvature, running from 10° to 12° and from 2 to 3 and 4 degrees.

*Dayton to Chillicothe.* — On the Toledo Division, exhibit 32, covering a distance of 80 miles with 2 trains per day. This is relatively level country encountering grades on some portions of 0.6 %. About 20 % of the division is curvature generally from 2° to 6°.

*Flora to Beardstown.* — On the Illinois Division, a distance of 154.1 miles with six trains per day. The profile is shown on Springfield Sub-Division, exhibit 33. This division runs through level country; about 10 % of this division is curvature ranging from 2° to 4° and in some few instances 5° to 6°.

*Flora to Shawneetown.* — On the Illinois Division, a distance of 74 miles. This is shown on the Springfield Sub-Division profile, exhibit 33. This is level country and about 10 % is curvature, running to between 1° and 2°.

*Indianapolis to Decatur.* — On the Indianapolis Division, covering a distance of 153 miles. We have no profile for this and it runs through generally level country with easy curvature of about 2°.

Generally speaking, there is a strong trend towards the use of motor rail cars because of their more economical operation, but the subject is complicated with the question as to what use are the light steam locomotives to be put when withdrawn from the little frequented lines. Many of these locomotives are in good serviceable condition and the disposition will be probably to wear them out on the little used trains on the more important lines and during the interim the developing of an acceptable design of rail motor car will take place.

The service and operation of the rail motor car as outlined on the Baltimore and Ohio Railroad is representative of the operation generally in the country, giving a wide scope of country and operating conditions.

The following is data from Baltimore and Ohio operation :

The speed of the motor car trains varies from 40 to 60 miles per hour. Gas con-

sumed is from 1 to 5 gallons per mile depending on the operating conditions.

	Cents
The average cost per train-mile for fuel gasoline . . . . .	6.82
The average cost per train-mile for lubricants . . . . .	0.49
The average cost of crew-motor-man, conductor and flagman per train mile . . . . .	18.78
Average maintenance cost of motors. . . . .	3.7
Average maintenance cost of cars and trailers per train-mile . . .	1.39
Average cost of miscellaneous supplies, etc., per train-mile . . .	3.41

The average cost of steam operation covering general expenses, operation and maintenance : minimum \$0.69, maximum \$1.79.

The average cost of the oil-electric engine is 32 cents per car handled, or 12.2 cents per engine-mile based on 6 miles per hour.

The average cost of the gasoline locomotive is 18.8 cents per car handled or 3.45 cents per engine-mile on 6 miles per hour basis.

The crew's wages for the oil-electric locomotive is 51.3 cents per engine-mile on 6 miles per hour basis.

The crew's wages for the gasoline locomotive is 41.3 cents per engine-mile on 6 miles per hour basis.

The Baltimore & Ohio has no one-man operated rail motor cars; they are usually handled by engineman, conductor, and in most cases an additional man either flagman or baggage-man is employed.

The cabs are located on the right side in front end of the car.

The rate of pay on the motor cars is based on that of the steam operated locomotives.

The following is data given by the New York Central Lines.

Economical operation on the branches of this system and certain main line divisions carrying relatively light traffic, has been accomplished in passenger service, only by the use of gasoline-mechanical or gasoline-electric rail motor cars.

The class of car, seating arrangement, power plant, equipment and number of cars used are governed by the local conditions to be met. The cars are of sufficient size and capacity to handle average traffic. Exceedingly heavy traffic during holidays is handled by steam equipment.

The most difficult rail car runs, with reference to speed, number of stops, schedule and profile, are represented by trains 76 and 69 of the St. Lawrence Division, New York Central Railroad.

No one man crews are being used. Each crew consists of two and sometimes three men.

Cars are stored at stations or engine houses, depending upon facilities available. Maintenance work is handled by mechanics picked from regular engine house forces.

Fuel performance varies in accordance with profile, speed and number of stops. An average figure for the gas-mechanical motor car operating without trailer is

2.5 miles per gallon and for the gasoline-electric cars, which as indicated by the attached data, are considerably larger and heavier, is 1.6 miles per gallon.

Average figures for total operating costs are as follows :

Gas-mechanical cars.	60 cents per mile.
Gas-electric cars . . .	65 cents per mile,
Steam trains . . .	95 cents per mile.

Average yearly mileage for the gas-mechanical units has been approximately 50 000. It is estimated that similar yearly mileage will be made by the gas-electric cars.

Average cost of gas-mechanical cars ranges from \$25 000 to \$35 000 and for the gas-electric single power plant cars, \$45 000 to \$50 000. The Diesel power plant gas-electric cars range from \$60 000 to \$85 000 each.

Rates of depreciation used, which is applied to the entire unit, are 14 % for the gas-mechanical and 10 % for the gas-electric cars.

It is planned to install additional cars wherever studies of local conditions indicate that it is economically practicable to do so.

Following this synopsis, a summary of detailed replies to the Questionnaire, made by the various railroads, will be found.

## Summary of detailed replies of various Railroads to questionnaire on Question XII.

A. — Organization of train services on the minor lines of the large systems carrying little traffic and of little used trains on the more important lines of these systems.

QUESTION 1. — What methods of economical traction do you employ for passenger trains on little frequented lines and for little frequented trains on more important lines?

### Answers.

*Baltimore & Ohio.* — For this service we are, in cases, using gas-electric motor cars, some operating with trailers, and in other cases straight gas cars are used. Generally, light steam locomotives are used which are available on account of not being economical in heavier service.

*Chesapeake & Ohio.* — Use the lighter type of steam locomotives with one combination baggage and mail car and one coach, manned by engine and train crews to meet the law requirements.

*Richmond, Fredericksburg & Potomac.* — In general, we employ light *Pacific* type locomotives equipped with superheaters; also gas-electric motor cars for little frequented trains on our line. In one instance, highway motor buses have superseded steam operated trains.

*Illinois Central.* — Gasoline operated motor cars and small steam locomotives.

*Philadelphia & Reading.* — Substituting gas-mechanical, gas-electric and oil-electric motor cars for steam.

*Central of Georgia.* — Light steam locomotives and gasoline rail cars.

*Louisville & Nashville.* — Gasoline-electric motor cars.

*Ulster & Delaware.* — Use nothing but steam locomotives.

*Pennsylvania.* — Gasoline or gasoline-electric.

QUESTION 2. — Light steam locomotives.

### Answers.

*Baltimore & Ohio.* — We still have in service on local trains, in branch line service, a number of light steam locomotives.

*Chesapeake & Ohio.* — Still have in service light steam locomotives.

*Richmond, Fredericksburg & Potomac.* — The majority of our little frequented passenger trains are handled by light *Pacific* type locomotives.

*Illinois Central.* — Still have in use light steam locomotives.

*Philadelphia & Reading.* — Still have in use nine American type (4-4-0) locomotives.

*Central of Georgia.* — Have in use eight- and ten-wheel type.

*Louisville & Nashville.* — None in use.

*Ulster & Delaware.* — No, regular steam power used in all passenger service.

*Pennsylvania.* — None in use.

QUESTION 3. — Locomotives propelled by gasoline engines?

### Answers.

*Baltimore & Ohio.* — We have one locomotive propelled by gasoline engine operating in light industrial switching service:

Total weight . . .	36 000 lb.
Tractive power . .	16 100 lb.
Fuel tank capacity.	50 gallons.

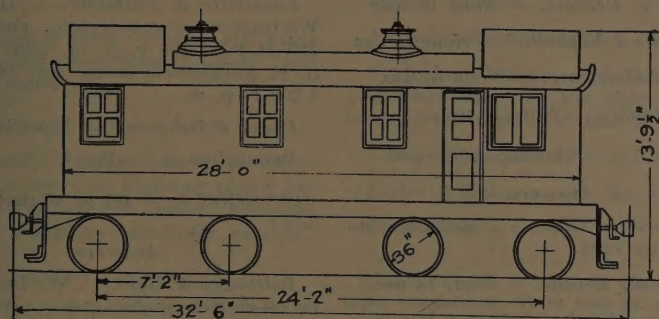


Exhibit 1. — Oil-electric locomotive No. 1, Class D. E., Baltimore and Ohio Railroad.  
Built by American Locomotive Co., General Electric Co. and Ingersoll Rand,  
Erie, Pa., 1925.

Total weight: 120 000 lb.  
Tractive power: 36 000 lb.  
Operating voltage: 600.  
Number of motors: 4.  
Type of motors: H M-640-G — D. C.  
Driver brake: W. A. B.

*Chesapeake & Ohio.* — None in use.

*Illinois Central.* — None in use.

*Richmond, Fredericksburg & Potomac.*  
— Not used.

*Philadelphia & Reading.* — None in use.

*Philadelphia & Reading.* — Not used.

*Central of Georgia.* — None in use.

*Central of Georgia.* — None in service.

*Louisville & Nashville.* — None in use.

*Louisville & Nashville.* — Not used.

*Ulster & Delaware.* — None in use.

*Ulster & Delaware.* — Not used.

*Pennsylvania.* — None in use.

*Pennsylvania.* — None in use.

QUESTION 5. — Electric storage battery locomotives.

QUESTION 4. — Locomotives propelled by internal combustion engines (Diesel engines)?

Answers.

Answers.

*Baltimore & Ohio.* — The only locomotive we have, propelled by internal combustion engine, is one operating in switching service at Twenty Sixth Street Pier, New York City. (See exhibit 1).

*Baltimore & Ohio.* — We have no oil or oil-electric motor cars.

*Chesapeake & Ohio.* — Have none in use.

*Richmond, Fredericksburg & Potomac.*  
— None in use.

*Illinois Central.* — None in use.

*Philadelphia & Reading.* — None in use.

*Chesapeake & Ohio.* — None in use.

*Richmond, Fredericksburg & Potomac.*  
— None in use.

*Central of Georgia.* — None in use.

*Louisville & Nashville.* — None in use.

*Ulster & Delaware.* — None in use.

*Pennsylvania.* — None in use.

QUESTION 6. — Steam motor cars.

Answers.

*Baltimore & Ohio.* — We have no steam motor cars.

*Chesapeake & Ohio.* — None in use.

*Richmond, Fredericksburg & Potomac.* — None in use.

*Illinois Central.* — None in use.

*Philadelphia & Reading.* — None in use.

*Central of Georgia.* — None in service.

*Louisville & Nashville.* — None in service.

*Ulster & Delaware.* — None in use.

*Pennsylvania.* — None in use.

QUESTION 7. — Gasoline or gasoline-electric motor cars.

Answers.

*Baltimore & Ohio.* — We use gasoline and gasoline-electric motor cars as mentioned in answer to question No. 1 and described in answer to question No. 42.

*Chesapeake & Ohio.* — None in use.

*Richmond, Fredericksburg & Potomac.* — We have one gasoline-electric motor car which has replaced steam operation in local passenger service.

*Illinois Central.* — Yes for passenger and express service.

*Philadelphia & Reading.* — Two gas-mechanical and six gas-electric.

*Central of Georgia.* — We have one gasoline rail car in service.

*Louisville & Nashville.* — One Brill-Westinghouse gas-electric motor car, 250 H. P., 1 100 r. p. m. One Sterling G. E. gas-electric motor car, 165 H. P., 1 200 r. p. m.

*Ulster & Delaware.* — None in use.

*Pennsylvania.* — Yes.

QUESTION 8. — Oil or oil-electric motor cars?

Answers.

*Baltimore & Ohio.* — We have no oil or oil-electric motor cars.

*Chesapeake & Ohio.* — Have none in use.

*Richmond, Fredericksburg & Potomac.* — None in use.

*Illinois Central.* — None in use.

*Philadelphia & Reading.* — None in use.

*Central of Georgia.* — None in use.

*Louisville & Nashville.* — None in use.

*Ulster & Delaware.* — None in use.

*Pennsylvania.* — None in use.

QUESTION 9. — Storage battery motor cars?

Answers.

*Baltimore & Ohio.* — None in use.

*Chesapeake & Ohio.* — None in use.

*Richmond, Fredericksburg & Potomac.* — None in use.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None in use.

*Louisville & Nashville.* — None in use.

*Ulster & Delaware.* — None in use.

*Pennsylvania.* — None in use.

QUESTION 10. — Other systems?

## Answers.

*Baltimore & Ohio.* — We are using *Atlantic and American* 8-wheel type steam locomotives.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — In one case highway motor buses have superseded steam operated trains in suburban passenger service.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None.

*Louisville et Nashville.* — None.

*Ulster & Delaware.* — None.

*Pennsylvania.* — None in use.

QUESTION 11. — Please show number of units by class and type, which you have in service, year of introduction and year of purchase of latest units of each type.

## Answers.

*Replies to this question are shown in the table on page 782.*

QUESTION 12. — Do you use similar methods for certain freight trains? If so, give information as above regarding motive power.

## Answers.

*Baltimore & Ohio.* — Steam locomotives are used for freight trains, except the one industrial freight switching locomotive as mentioned in answers to Questions 3 and 4.

*Chesapeake & Ohio.* — No.

*Richmond, Fredericksburg & Potomac.* — For local freight trains we employ light *Pacific* power similar to those described in answer to Question 11.

*Illinois Central.* — No.

*Philadelphia & Reading.* — No.

*Central of Georgia.* — Light steam locomotives only. — Six light 10-wheel locomotives in service; 1890 to 1896.

*Louisville & Nashville.* — No.

*Ulster & Delaware.* — No.

*Pennsylvania.* — No.

QUESTION 13. — Among the motor car types enumerated, which ones do you intend to discontinue? What are the reasons?

## Answers.

*Baltimore & Ohio.* — Will eventually discontinue the three (3) gasoline cars, as they are limited to capacity and trailer load.

*Chesapeake & Ohio.* — No motor car types.

*Richmond, Fredericksburg & Potomac.* — None discontinued.

*Illinois Central.* — Discontinued none. Will not purchase in the future any gasoline car operated direct drive, but the electric drive instead for all horsepower of 175 and above.

*Philadelphia & Reading.* — The purchase of the gas-mechanical cars has been discontinued on account of being too small.

*Central of Georgia.* — We have one gasoline rail car only put into service in 1928. We do not intend to discontinue the use at present.

*Ulster & Delaware.* — None.

*Louisville & Nashville.* — None.

*Pennsylvania.* — Some of the earlier types of straight gasoline as they are too light.

Railroad.	DESCRIPTION.	Introduction, year.	Purchase latest unit.
<i>Baltimore &amp; Ohio . . .</i>	3 gasoline-motor passenger and baggage cars.	1923	1925
	16 gas-electric passenger cars.	1927	1928
	1 gas-electric passenger-baggage and mail car.	1928	
	1 oil-electric switching locomotive.	1925	
	1 gasoline locomotive switcher.	1926	
<i>Chesapeake &amp; Ohio . .</i>	1 4-4-0, 8-wheel passenger.	1905	1905
	1 4-4-0, 8-wheel passenger.	1907	1907
<i>Illinois Central . . . .</i>	2 gasoline direct drive motor cars.	1926	
	2 gasoline, electric drive motor cars.	1914	
<i>Philadelphia &amp; Reading</i>	9 American type steam-locomotives.	1885	1904
	2 8-wheel passenger cars. Gasoline-mechanical.	1923	1923
	6 8-wheel passenger cars. Gasoline-electric.	1925	1928
<i>Central of Georgia . .</i>	35 light 8-wheel steam locomotives.	1882	
	3 light 10-wheel steam locomotives.	1890	
	1 gasoline rail car put in service.	1928	
<i>Louisville &amp; Nashville .</i>	1 Sterling G. E. gas-electric motor car.	1926	
	1 Brill-Westinghouse gas-electric motor car.	1928	
<i>Richmond, Fredericks- burg &amp; Potomac.</i>	1 gasoline-electric motor car with trailer which is replaced by steam operation on certain local passenger schedules. For local passenger service use light Pacific type locomotive.	1928 1905	
<i>Ulster &amp; Delaware . .</i>	None.		
<i>Pennsylvania . . . .</i>	13 gasoline. Weight from 29 500 to 55 000 lb.	1922	1926
	18 gasoline-electric.	1925	1928
	5 are 60 ft. long. — 250 H.P. — 90 000 lb.		
	1 is 73 ft. long. — 240 H.P. — 116 000 lb.		
	6 are 73 ft. long. — 275 H.P. — 122 000 lb.		
	6 are 73 ft. long. — 350 H.P. — 132 000 lb.		

QUESTION 14. — By what types do you intend to replace them?

Answers.

*Baltimore & Ohio.* — Gasoline-electrics, or Diesel engines if and when development of latter type reaches point where adoption is justified.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — None.

*Illinois Central.* — None at the present.

*Philadelphia & Reading.* — Gas-electric for oil-electric.

*Central of Georgia.* — This has not been decided.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — None.

*Pennsylvania.* — Electric transmission type.

QUESTION 15. — Give the following description, information for each of the types enumerated in reply to Question 11. — Sketches.

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.* — No motor car types.

*Richmond, Fredericksburg & Potomac.* — See exhibits 13 to 16.

*Illinois Central.* — ...

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibits 11 and 12.

*Ulster & Delaware.* — No motors.

QUESTION 17. — Distance center to center of trucks?

Answers.

*Baltimore & Ohio.*

Class G-1 . . . . .	16 ft. 0 in.
Class G-2, G-3 . . . . .	32 ft. 0 in.
Class GE-1, GE-2, GE-5, GE-6 . . . . .	41 ft. 3 1/4 in.
Class GE-7 . . . . .	53 ft. 9 in.

*Chesapeake & Ohio.* — No motor car types.

*Richmond, Fredericksburg & Potomac.*  
 Front truck, 7 ft. 9 in.  
 Back truck, 7 ft. 6 in.

*Illinois Central.*  
 Motor truck, 6 ft. 10 in. and 8 ft. 4 in.  
 Trailer truck, 7 ft. 0 in. and 6 ft. 0 in.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibits 11 and 12.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.*  
 Gasoline, 22 ft. 2 in., 22 ft. 3 in. and 32 ft. 0 in.  
 Gasoline-electric, 41 ft. 6 in. and 53 ft. 6 in.

QUESTION 18. — Total wheel base.

Answers.

*Baltimore & Ohio.*

G-1 . . . . .	20 ft. 8 in.
G-2, G-3 . . . . .	62 ft. 8 in.
GE-1 . . . . .	48 ft. 1 1/4 in.
GE-2, GE-3, GE-5, GE-6 . . . . .	48 ft. 3 1/4 in.
GE-7 . . . . .	60 ft. 8 1/4 in.

*Chesapeake & Ohio.* — No motor car types.

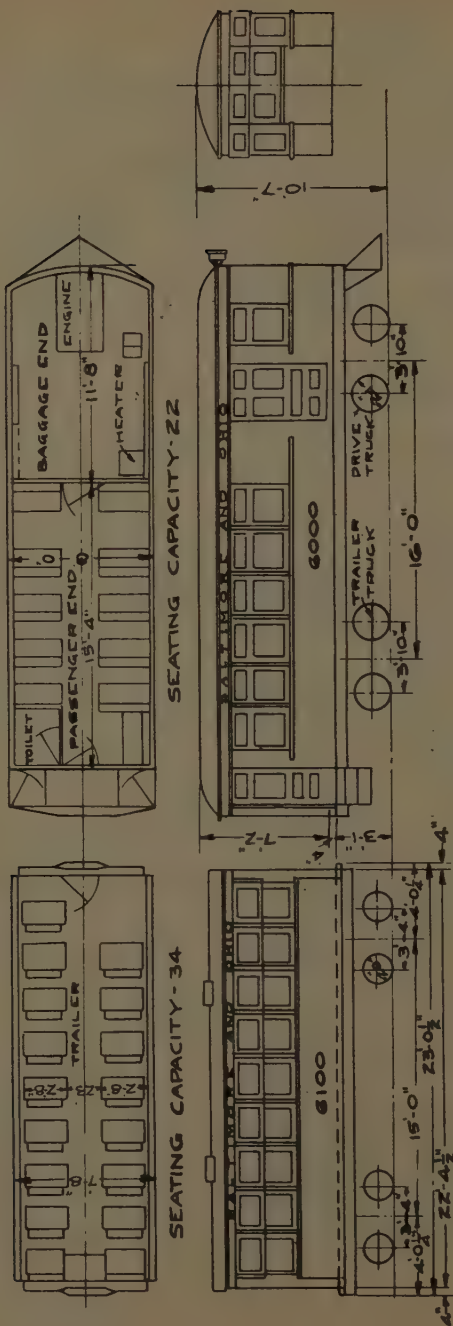


Exhibit 2. — Gas motor car, Class G-Is, No. 6000, and trailer, Class T-Is, No. 6100, Baltimore and Ohio Railroad.

*Trailer for gas motor car.*

Light weight : 9 350 lb.  
 Brakes : W. A. B. Co. semi-aut. air and hand.  
 Heating : Peter Smith, hot air.  
 Lighting : Electric.  
 Built by Edwards Ry. Motor Car Co., 1922.  
 Construction : All steel.

*Gas motor car.*

Power plant :  
 4-cylinder 4 3/4 in. diam., 6 in. stroke.  
 Engine H. P. : 68 at 1 800 r. p. m.  
 Control : Single end.  
 Light weight, front truck  
 Light weight, rear truck

Total light weight . . . . . 18 150

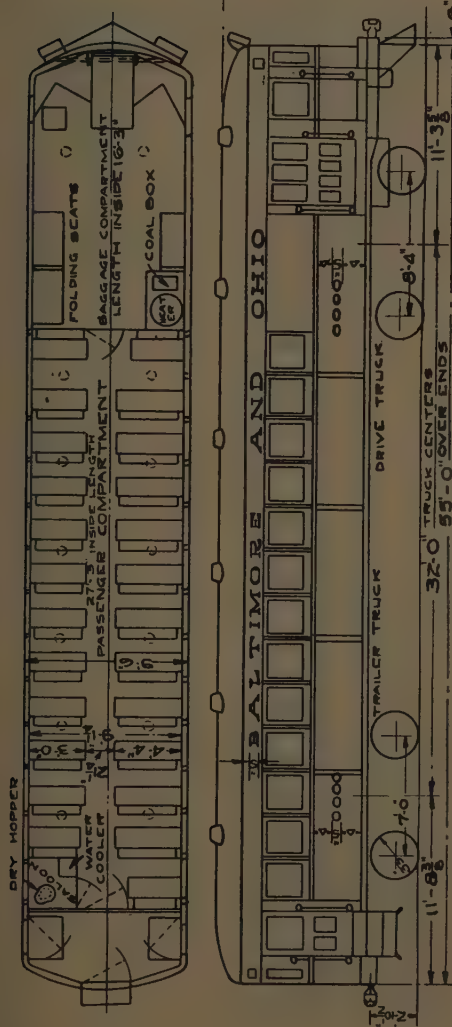


Exhibit 3. — Gas motor car No. 6001, Class G-2, Baltimore and Ohio Railroad.

Seating capacity:		
Passenger compartment	61	
Baggage	6	
Total	67	
Power plant:		
6-cylinder, 6 in. diam., 7 in. stroke.		
Valves per cylinder: 4.		
Engine H. P.: 120 at 1 300 r. p. m.		
Control: Single end.		
Brakes: W. A. B. Co., air and hand.		
Heating: Peter Smith, hot water.		
Lighting: Electric.		
Built by: J. G. Brill, 1923.		
Construction: All steel.		
Light weight, front truck	34 850 lb.	
Light weight, rear truck	21 650 lb.	
Total light weight	56 450 lb.	



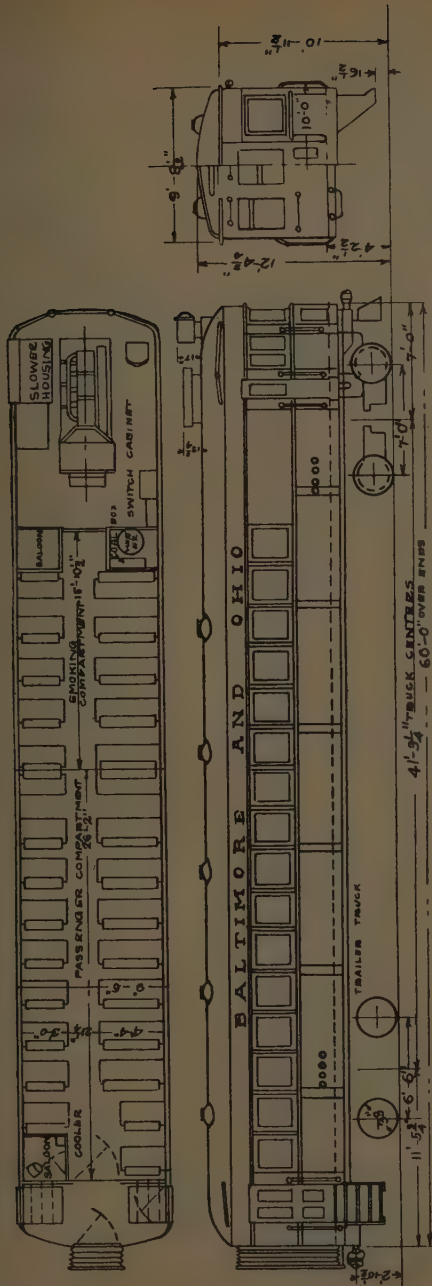


Exhibit 5. — Gas-electric motor car No. 6030, Class G. E.-1, Baltimore and Ohio Railroad.

Truck motors, each: 140 H. P.

Control: Single end.

## Seating

Passenger compartment

Total . . . 71

Power plant:

Engine: Brill-Westinghouse.

6-cylinder, 7 1/4 in. diam., 6 in. stroke.

Valves per cylinder: 4.

Engine H. P.: 250 at 1 100 r. p. m.

One generator, West. type: 176-A.

Capacity of generator: 160 kw., 600 volts.

Two truck motors. West., 557 D-8.

Light weight, front truck . . .	57 900 lb.
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Light weight, rear truck . . .	35 300 lb.
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Total light weight .	93 200 lb.
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Brakes: West, A. M. L.

Heating: Peter Smith,

Lighting: Electric.

Built by: J. G. Brill, 1927.

Construction: Steel.

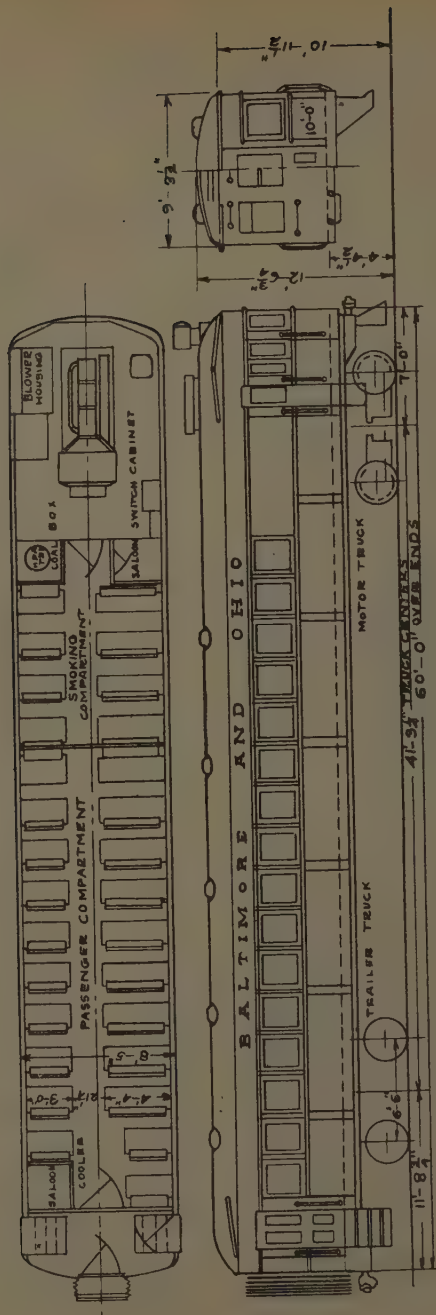


Exhibit 6. — Gas electric motor cars Nos. 6031 to 6034, Class G. E. 2, Baltimore and Ohio Railroad.

Truck motors : 250 H. P.  
 Gear ratio : 18/61  
 Control : Single end.

Seating capacity :  
 Passenger compartment . . . . . 51  
 Smoking compartment . . . . . 29

Total . . . . . 71

Power plant :  
 Engine : Brill-Westinghouse,  
 6-cylinder, 7 1/4 in diam., 8 in. stroke.  
 Valves per cylinder : 4.  
 Engine H. P. : 250 at 1 100 r. p. m.  
 One generator, West. type, 175-A-2.  
 Capacity of generator : 160 kw., 900 volts.  
 Two truck motors, West. 560-C-4.

Light weight, front truck . . . . . 39 250 lb.  
 Light weight, rear truck . . . . . 34 740 lb.  
 Total light weight . . . . . 74 000 lb.

Brakes : Westing. A. M. I.  
 Heating : Peter Smith, hot water.  
 Lighting : Electric.  
 Built by : J. G. Brill, 1927.  
 Construction : Steel.

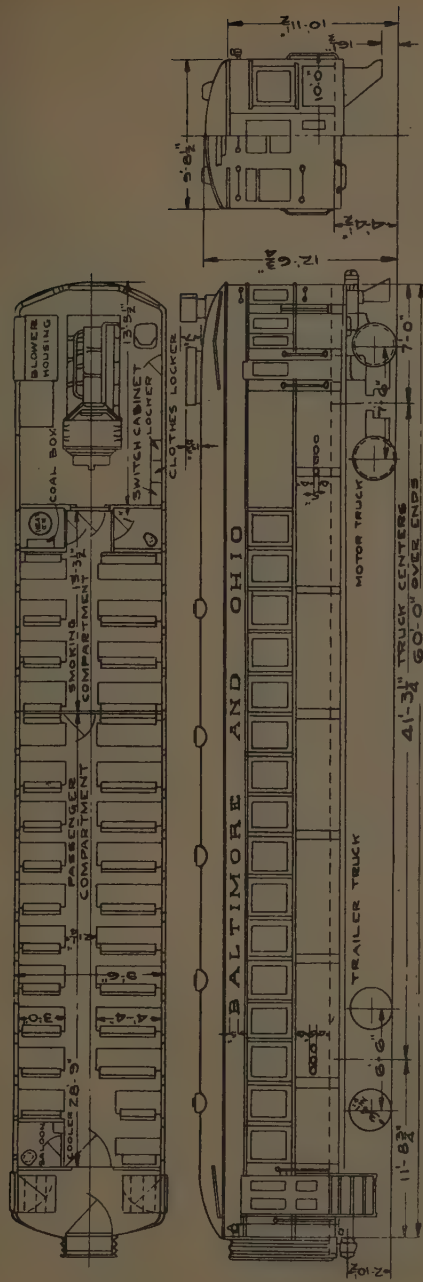


Exhibit 7. — Gas-electric motor cars Nos. 6035 to 6042, 6044 and 6045, Class G. E.-3, Baltimore and Ohio Railroad.

Truck motors : 250 H. P.

Gear ratio : 18/61.

Control : Single end.

Seating capacity :

Passenger compartment . . . . .	51
Smoking compartment . . . . .	20
Total . . . . .	71

Power plant :

Engine : Brill-Westinghouse.

6-cylinder, 7 1/4 in. diam., 8 in. stroke.

Valves per cylinder : 4.

Engine H. P. : 250 at 800 r. p. m.

One generator, Westinghouse, 170-42.

Capacity of generator : 160 kw., 600 volts.

Two truck motors, Westinghouse 500-G. 4.

Light weight, front truck . . . . . 59 800 lb.

Light weight, rear truck . . . . . 34 900 lb.

Total light weight . . . . . 94 700 lb.

Brakes : West. A. M. L.

Heating : Peter Smith, hot water.

Lighting : Electric

Built by : J. G. Brill, 1927 and 1928.

Construction : All steel.



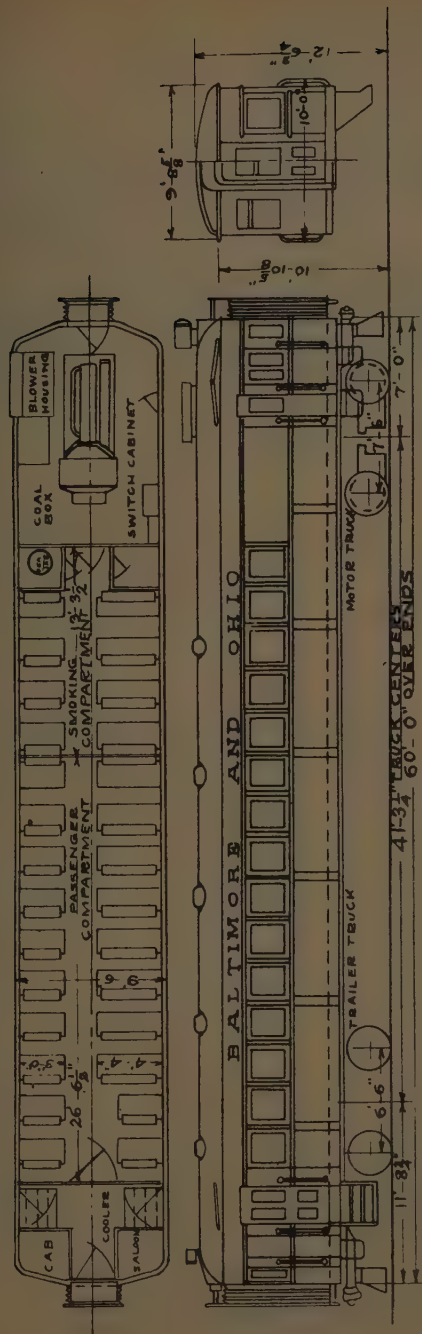


Exhibit 9. — Gas-electric car No. 6043, Class G, E.-6, Baltimore and Ohio Railroad.

Truck motors : 250 H. P.  
 Gear ratio : 18/61.  
 Control : Double end.

Seating capacity :  
 Passenger compartment . . . . . 48  
 Smoking compartment . . . . . 20  
 Total . . . . . 68

Power plant :  
 Engine : Brill-Westinghouse,  
 6-cylinder, 7 1/4 diam., 8 in. stroke.  
 Valves per cylinder : 4.  
 Engine H. P. : 250 at 1100 r. p. m.  
 One generator : West. 178-A-2.  
 Capacity of generator : 150 kw., 600 volta.  
 Two truck motors : West. 569 C-4.

Light weight, truck (eng. end), . . . 60 681 lb.  
 Light weight, rear truck . . . . . 38 319 lb.  
 Total light weight . . . . . 99 000 lb.

Brakes : West. A. M. L.  
 Heating : Peter Smith, hot water.  
 Lighting : Electric.  
 Built by : J. G. Brill Co.  
 Construction : Steel.

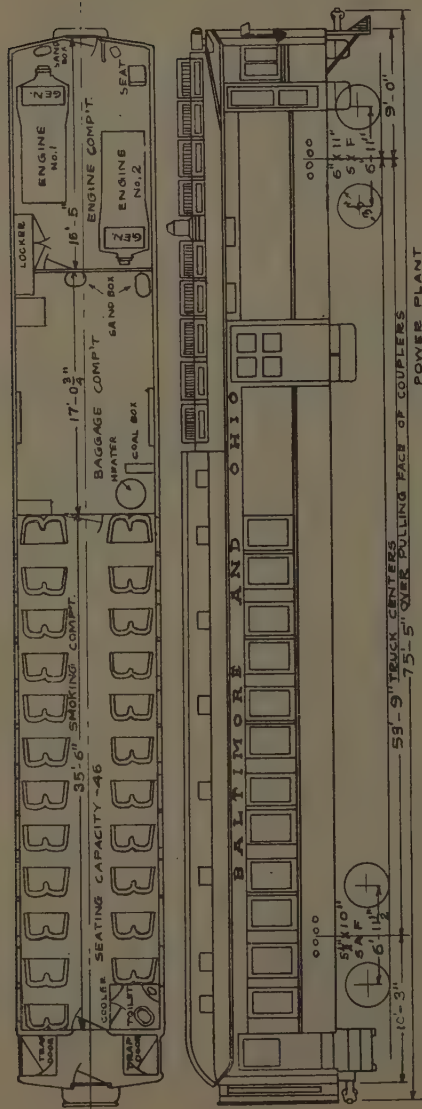


Exhibit 10. — Gas-electric motor car No. 6500, Class G. E.-7, Baltimore and Ohio Railroad.

Total light weight . . . 1  
Heating: Peter Smith, hot water.

Lighting: Electric.

Built by Standard Steel Car Co., 1928.

Construction: All steel.

Truck motors, each: 250 H. P.

Control; Single end.

Sitting capacity:

Smoking compartment: 46.

Power plant:

engines · Sterling Viking type.

6 cylinders, each 7 1/2 in. diam., 9 in. stroke.

Valves per cylinder: 4.

Engine H. P.: 200 at 1100 r. p. m.

Two generators: Westingh. type 181.

Capacity of each genr.: 210 kw., 600 volts.

Four truck motors: Westingh. 589 C-A-4.

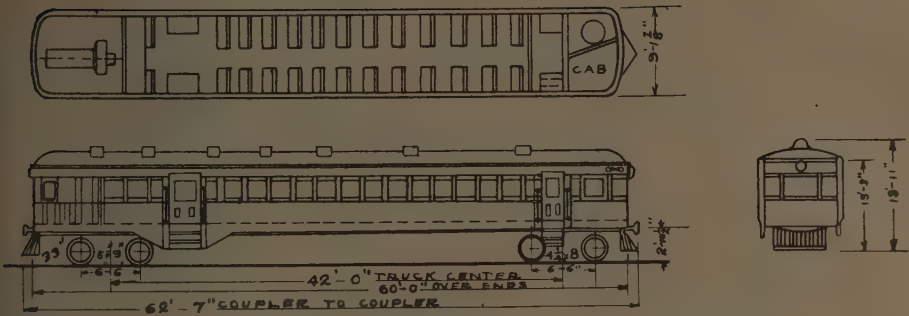


Exhibit 11. -- Gas-electric passenger motor car No. 90, Louisville and Nashville Railroad Company.

Builder: J. G. Brill Co.  
Date built: 1926.  
Fuel: Gasoline.  
Gas engine: Dolphin.  
Cylinders: 7  $1\frac{1}{4}$ "  $\times$  8".  
H. P.: 225 at 1400 r. p. m.  
Generator, G. E.-T. D. C. 6-105.  
Motors, G. E. 240-E (2 mot.).  
Air compressor, G. E.-C. P. 128-01.  
Transmission: Electric.  
Air brake: West. A. B. M.

Air signal: West. A. B. M.  
Batteries: Exide.  
Truck: Brill.  
Capacity of gas. tank: 150 gall.  
Cooling system: Fin and tube.  
Circle cooling.  
Cooling radiation.  
Fuel feed: Vacuum.  
Heater: Peter Smith. — Radiation.  
Capacity: 86 passengers.

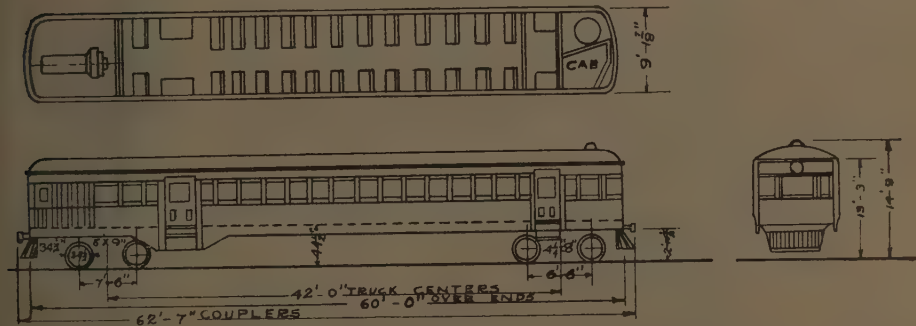


Exhibit 12. - Gas-electric passenger motor car No. 91, Louisville and Nashville Railroad Company.

Builder: J. B. Brill Co.  
Date built: 1928.  
Fuel: Gasoline.  
Gas engine: Brill-W.  
Cylinders: 7  $1\frac{1}{4}$ "  $\times$  8".  
H. P.: 250 at 1100 r. p. m.  
Generator: W. E. Co., No. 34-E-286.  
Motors: W. E. 569-2-230 H. P.  
Air compressor: W. E. D. H.-25.  
Transmission: Electric.  
Air brake: West. A. B. M.

Air signal: West. A. B. M.  
Batteries: Exide M. Y. E. 13-2.  
Truck: Brill.  
Capacity of tank: 150 gall.  
Cooling system: Fin and tube.  
Circle cooling.  
Cooling radiation.  
Fuel feed: Vacuum.  
Heater: Peter Smith. — Radiation.  
Capacity: 81 passengers.

Construction: All steel.

Lighting: Electric.

Weight, front end . . . . . 87 260 lb.

Weight, rear end . . . . . 59 140 lb.

Journals, front truck: 5  $1\frac{1}{2}$ "  $\times$  10"

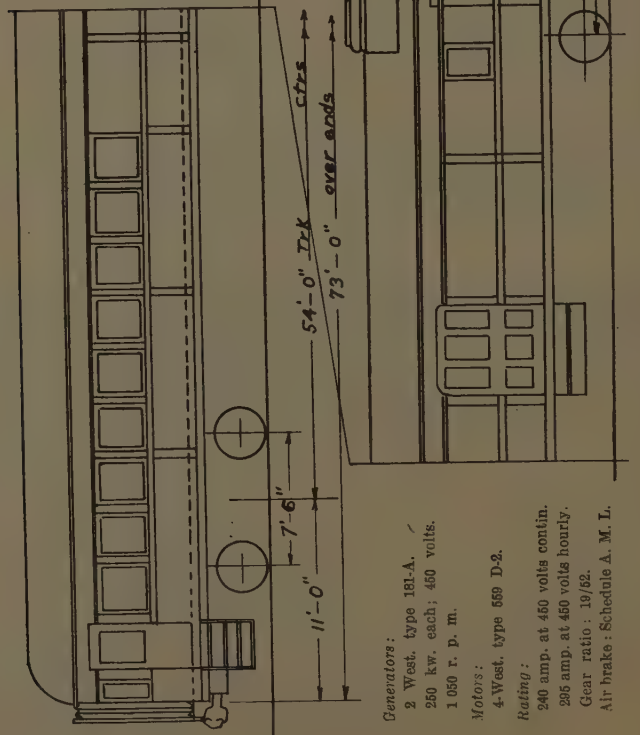
Journals, rear truck: 9"  $\times$  9"

Total . . . . . 146 400 lb.

Tractive effort: 23 000 lb.

Engines: 2 Hall-Scott 6-cyl. gas. motors, 275 H. P. each; cylinders 7  $1\frac{1}{2}$ "  $\times$  9".

Built 1928 by J. G. Brill Co.



#### Generators:

2 West, type 181-A, ✓  
250 kw. each; 450 volts.  
1 050 r. p. m.

#### Motors:

4-West, type 569 D-2.

#### Rating:

240 amp. at 450 volts contin.

256 amp. at 450 volts hourly.

Gear ratio: 19/62.

Air brake: Schedule A. M. L.

Exhibit 13. — Gas-electric cars M-1, Richmond, Fredericksburg and Potomac Railroad.

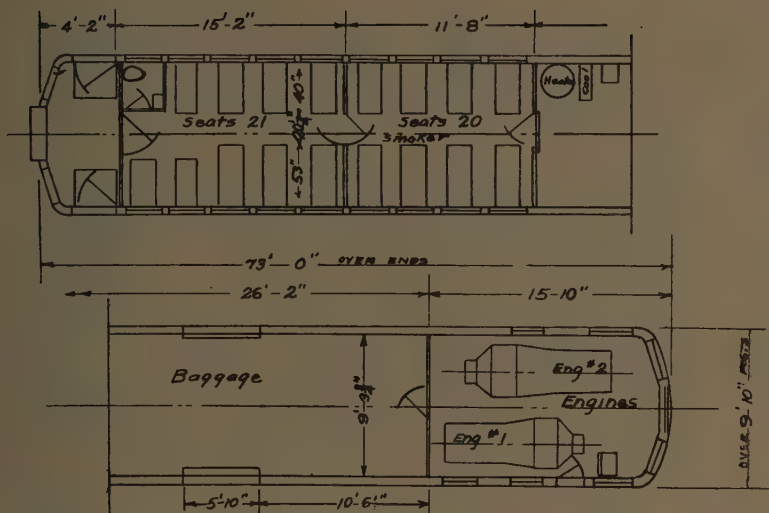


Exhibit 14. — Gas-electric rail cars, Richmond, Fredericksburg and Potomac Railroad.

*Richmond, Fredericksburg & Potomac.*

Gasoline electric motor car, 34 1/2 feet.

Pacific type locomotive, 69 feet.

*Illinois Central.* — All cars and locomotives, leading truck, 33 feet.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibits 11 and 12.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.*

Gasoline, 30 ft. 0 in., 30 ft. 1 in. and 39 ft. 8 in.

Gasoline-electric, 48 ft. 3 in. and 60 ft. 4 1/2 in.

QUESTION 19. — Diameter of wheels ?

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.* — No motor car types.

*Richmond, Fredericksburg & Potomac.* — See exhibits 13 to 16.

*Illinois Central...*

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibit 11 and 12.

*Ulster & Delaware.* — No motors.

*Pennsylvania.*

Gasoline, 30 and 33 inches.

Gasoline-electric, 33 and 36 inches.

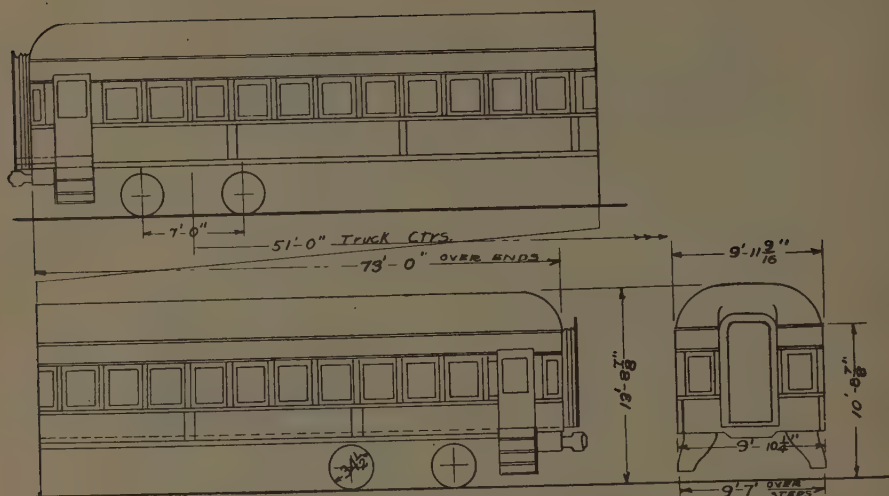


Exhibit 15. — Trailing cars T-11, Richmond, Fredericksburg and Potomac Railroad.

Construction: All steel.  
Lighting: Electric.  
Weight: 82 680 lb.  
Journals: 5" x 9".

Roller bearings.  
Air brake: Schedule.  
Built by J. G. Brill Co., 1928.

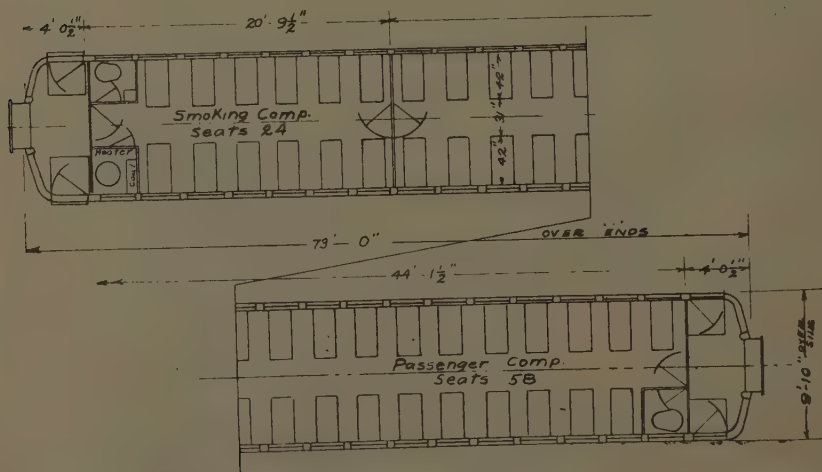


Exhibit 16. — Trailing cars T-11, Richmond, Fredericksburg and Potomac Railroad.

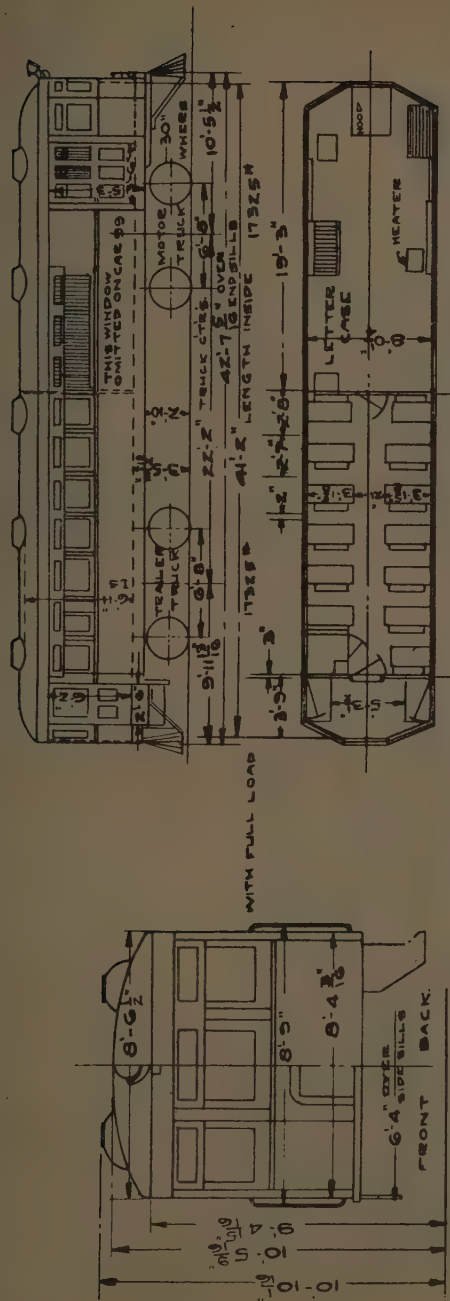


Exhibit 17. — Combination passenger and baggage gasoline motor car Nos. 98 and 99, Philadelphia and Reading Railroad.

Builder: J. G. Brill Co.

Date: No. 99, Jan. 1923; No. 98, Sept. 1923.

Approx. weight: 26 000 lb.

Ventilators: Pass. 6, Bagg. 4.

Framing: Steel underframe.

Engine: 4-cycle, 4-cyl., 4 3/4" x 6", 98 H. P. at 1 000 r. p. m.

Length bagg. compartment: 19'-3".

Length passenger compartment: 17'-9 1/2".

Saloon: One, left side.

Heating: Hot air and water.

Lighting: Electricity.

1/2" bars bagg. r. m.: Windows and doors.

Capacity No. 98: Pass. 26, Bagg. 5.

Capacity No. 99: Pass. 26, Bagg. 4.



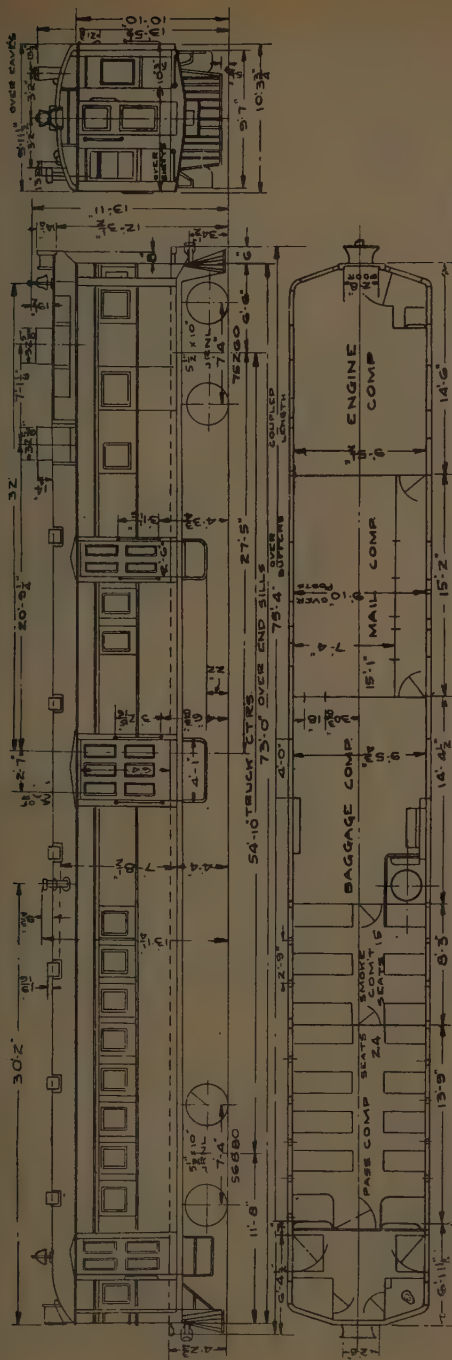


Exhibit 19. — Passenger, baggage and mail gas-electric car No. 76, Class E D f, Philadelphia and Reading Railroad.

Builder : Mack Inter. Motor Truck Co.

Date : August 1923.

Seating capacity : 30.

Weight : 132 140 lb.

Framing : Steel.

Engines : Three — 6-cyl. gasoline.

Horse power : 120 at 1 350 r. p. m.

Cylinders : Six — 5" x 6".

Generator : 180-A-4 West. 95 kw.

Motors : 3 : 550-D-2 West. — 150 H. P.

Gear ratio : 19/52 — 38" wheels.

Speed, 0.5 % grade : 64.5 m. p. h.

Speed, 1 % grade : 45 m. p. h.

Speed, 2 % grade : 32.5 m. p. h.

Speed, 40-ton trailer, 0.5 % grade : 42 m. p. h.

Speed, 40-ton trailer, 1 % grade : 33 m. p. h.

Speed, 40-ton trailer, 2 % grade : 21.6 m. p. h.

Tractive effort, 5 m. p. h. : 13 600 lb.

Tractive effort, 10 m. p. h. : 9 200 lb.

Tractive effort, 20 m. p. h. : 5 160 lb.

Tractive effort, 50 m. p. h. : 2 100 lb.

Mail capacity : 4 600 lb.— 770 cubic feet.

Heating : Vapor Co. H. W.

Lighting : Electric.

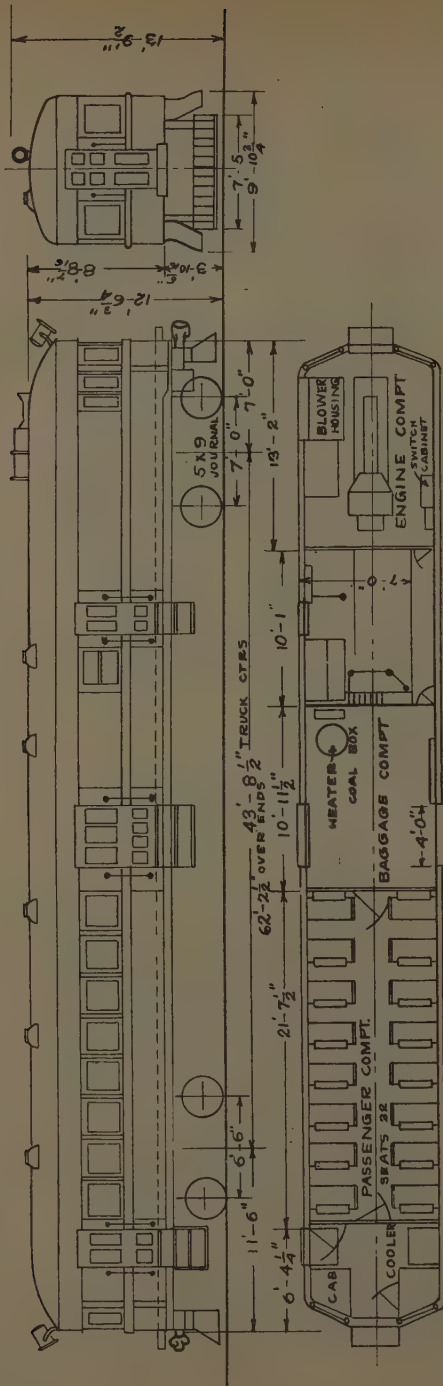
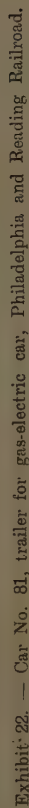


Exhibit 20. Passenger and baggage gas-electric cars, Class E D c, Philadelphia and Reading Railroad.

Builder	J. G. Brill Co.	Side door, mail, width	2'-0"
Date	February 1928.	Engine	Brill, 6-cyl., 7 1/4" diam., 8" stroke.
Weight	95150 lb.	Motors	250 H. P. at 1100 r. p. m.
Seating capacity	32.		Two West. type 557 A-8; 140 H. P. each.
Framing	Steel.	Gear ratio	19/58.
Saloon	One right side.	Transmission	Electric.
Heating	Baker, hot water.	Weight, body	64 470 lb.
Lighting	Electric.	Weight, front truck and 2 motors	20 810 lb.
End doors, width	2'-6"	Weight, rear truck	9 870 lb.
End doors, height	6'-2"	Tractive effort at 5 m. p. h.	10 100 lb.
Slide door, baggage, width	4'-0"	Draw bar pull	9 800 lb.
Vestibule side door, width	2'-5 5/8"		





End doors, width: 2'-6".

End doors, height: 6'-2".  
Vest. side door, width: 2'-5 5/8"



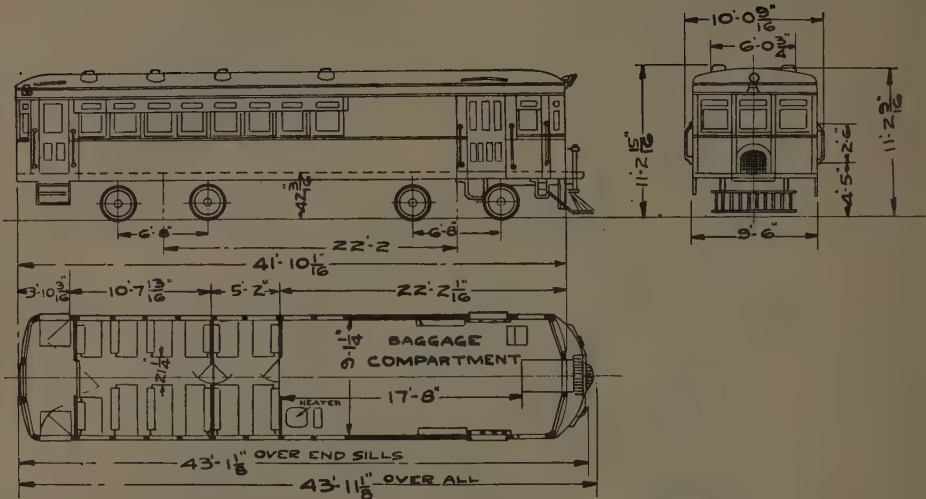


Exhibit 24. — Gasoline rail car No. 10, Central of Georgia Railroad.

Builder: J. G. Brill Co. (Model 55).

Date built: November 1928.

Weight: 32 000 lb.

Journals: 8" diam., Timken roller bearings.

Wheels: 30", cast steel, steel tires.

Air brakes: Westinghouse D. H. B. 10, compressor.

Hand brake: Each end of car.

Roof: Poplar covered with canvas.

Doors: Rear vestibule 29 5/8", baggage room 42".

Trap doors: Edwards 3 V-in rear vestibule.

Windows: Double sash.

Vestibule: Each end of car.

Lighting system: Electric, 12 volts.

Heating system: Peter Smith No. 2-C, hot water.

Headlight: Golden glow H. D. B.-96.

Marker lights: Brackets each end of car.

Fire extinguisher: Pyrene.

Couplers: Pull socket each end.

Pilot-Steel.

Ventilators: 10 Brill. Exhaust in roof.

Engine: Continental model, 16 H., six-cyl.

Bore 4 1/2", Stroke 5 3/4", H. P.: 92 at 1500 r. p. m., normal speed.

Seating capacity: 29.

QUESTION 20. — Length over buffers ?

Answers.

*Baltimore & Ohio.*

G-1 . . . . .	31 ft. 7 in.
G-2, G-3 . . . . .	58 ft. 1 in.
GE-1, GE-2, GE-3, GE-5, GE-6 . . . . .	61 ft. 11 1/4 in.
GE-7 . . . . .	75 ft. 5 in.

*Chesapeake & Ohio.* — No motor car types.

*Richmond, Fredericksburg & Potomac.* — Electric motor car, 75 ft. 1/2 in.

*Illinois Central.*

Motor cars, 70 ft. 3 1/2 in.

Motor cars, 55 ft. 6 in.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibits 11 and 12.

*Ulster & Delaware.* — None.

*Pennsylvania.*

Gasoline, 42 ft. 7 5/16 in., 43 ft. 7 in. and 55 ft. 0 in.

Gasoline-electric, 60 ft. 0 in. and 73 ft. 0 in.

QUESTION 21. — Length of body for motor cars, locomotives and cars?

#### Answers.

*Baltimore & Ohio.*

Class G-1 . . . . . 29 ft. 7 in.

Class G-2, G-3 . . . . . 55 ft. 0 in.

Class GE-1, GE-2, GE-3,

GE-5, GE-6 . . . . . 60 ft. 0 in.

Class GE-7 . . . . . 73 ft. 0 in.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Gasoline-electric motor car, 73 ft. 0 in.

*Illinois Central.*

Nos. 113 to 116 motor cars, 55 ft. 0 in.

Nos. 117 to 120 motor cars, 66 ft. 4 in.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — See exhibits 11 and 12.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Same as No. 20.

QUESTION 22. — Gauge of track?

#### Answers.

Standard (4 ft. 8 1/2 in.) on all systems.

QUESTION 23. — Type of motor (steam, explosion, alcohol, gasoline, oil, gas, heavy oil engine)?

#### Answers.

*Baltimore & Ohio.*

Class G-1, gasoline, chain drive.

Class G-2, G-3, gasoline, gear drive.

Class GE-1, GE-2, GE-3, GE-5, GE-6, GE-7, gasoline, electric drive.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Gasoline-electric.

*Illinois Central.* — Gasoline.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — Gasoline.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No motors.

*Pennsylvania.* — Explosion gasoline.

In the case of steam motive power.

QUESTION 24. — Type of boiler, with details of special system?

#### Answers.

*Baltimore & Ohio.* — We use the conventional type radial stay locomotive boiler.

*Chesapeake & Ohio.* — Belpaire fire-tube type, rounded backhead equipped with brick arch.

*Richmond, Fredericksburg & Potomac.* — Straight top, wide firebox radial stayed, firebox equipped with two thermic syphons.

*Illinois Central.* — Small 8-wheel locomotives with the usual type of wagon top boiler. Have no special system.

*Philadelphia & Reading.* — Wooten type firebox boiler.

*Central of Georgia.* — Wagon top boiler with narrow firebox. No special system.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

(On Stony Cove & Hunter Branch):

Wagon top type, narrow firebox (20 class engine, saturated).

(On main line):

Wagon top type wide firebox (30 class superheater) with helper engine with wagon top type, narrow firebox (20 class superheated).

*Pennsylvania.* — Not used

QUESTION 25. — Number of tubes, inside diameter and length.

Answers.

*Baltimore & Ohio.* — The tubes are 2 inches inside diameter, 2-1/4 inches outside diameter and varying in length on the different equipment from 11 to 15 feet.

*Chesapeake & Ohio.*

1 unit-241 tubes, 1 3/4 inches I. D. — 11 ft. 7 1/16 in. long.

1 unit-270 tubes, 1 3/4 inches I. D. — 11 ft. 7 1/16 in. long.

*Richmond, Fredericksburg & Potomac.*

114 tubes, 2-1/4 in. diameter, length 19 ft. 6 in.

24 flues, 5-1/2 in. diameter, length 19 ft. 6 in.

*Illinois Central.*

232 tubes, 11 ft. 7 1/8 in. long., 2 in. O. D., 1 3/4 in. I. D.

*Philadelphia & Reading.* — From 237 to 324 tubes. Diameter: 1 1/2, 1 3/4 or 2 inches.

*Central of Georgia.* — From 161 to 250 tubes. Diameter : 2 inches.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20 class-saturated — 320, 1 3/4 in. I. D., 14 ft. long.

20 class-superheated — 166, 1 3/4 in. I. D., 14 ft. long.

30 class-superheated — 169, 1 3/4 in. I. D., 14 ft. 4 in. long.

30 class-superheated — 24, 5 in. I. D., 14 ft. 4 in. long.

*Pennsylvania.* — Not used.

QUESTION 26. — Heating surface. — a) For saturated steam?

Answers.

*Baltimore & Ohio.* — The American 8-wheel saturated steam locomotive has a heating surface of 1 555.44 square feet.

*Chesapeake & Ohio.*

1 unit : 1618.86 square feet.

1 unit : 1793.48 square feet.

*Richmond, Fredericksburg & Potomac.*

Firebox . . . . . 136 square feet

Tubes . . . . . 1 389 square feet

Arch tube . . . . . 14 1/2 square feet

Tot. saturated steam 1 539 1/2 square feet

*Philadelphia & Reading.* — From 1 320 to 1 614 sq. feet.

*Central of Georgia.* — From 1 038.4 to 1 650 sq. feet.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — 2 496 sq. feet.

*Pennsylvania.* — Not used.

QUESTION 27. — b) For superheated steam.

Answers.

*Baltimore & Ohio.* — The Atlantic type superheated steam locomotive has a total heating surface of 1 890.16 square feet, and the superheating surface is 414 square feet additional.

*Chesapeake & Ohio.* — None superheated.

*Richmond, Fredericksburg & Potomac.* — 553 square feet.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None of these locomotives superheated.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20 class — 2 233 square feet.

30 class — 2 285 square feet.

*Pennsylvania.* — Not used.

QUESTION 28. — Average and maximum temperature of superheat (Fahrenheit)?

Answers.

*Baltimore & Ohio.* — Average temperature superheat 604° F., maximum 725° F.

*Chesapeake & Ohio.* — None superheated.

*Richmond, Fredericksburg & Potomac.* —

*Illinois Central.* — None.

*Central of Georgia.* — No superheat.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Average 666° F., maximum, 720° F.

*Pennsylvania.* — Not used.

QUESTION 29. — System of superheating.

Answers.

*Baltimore & Ohio.* — The Schmidt double loop type design superheater is used.

*Chesapeake & Ohio.* — None superheated.

*Richmond, Fredericksburg & Potomac.* — The Superheater Company's "A".

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Elesco type "A" (Schmidt).

*Pennsylvania.* — Not used.

QUESTION 30. — Working pressure (lb. per square inch.).

Answers.

*Baltimore & Ohio.* — The boiler pressure on the American 8-wheel is 170 lb. and on the Atlantic type 205 lb.

*Chesapeake & Ohio.* — 180 lb.

*Richmond, Fredericksburg & Potomac.* — 200 lb. per square inch, gauge pressure.

*Illinois Central.* — 165 to 175 lb.

*Philadelphia & Reading.* — 160 lb. minimum, 180 lb. maximum.

*Central of Georgia.* — From 125 to 180 lb.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — 200 lb.

*Pennsylvania.* — Not used.

QUESTION 31. — Nature of fuel, peculiarities of method of firing (for example oil while running, coal when standing).

Answers.

*Baltimore & Ohio.* — Use run-of-mine bituminous coal on both classes of locomotives, they being hand fired.

*Chesapeake & Ohio.* — Bituminous coal, hand fired only.

*Richmond, Fredericksburg & Poto-*  
*mac.* — Bituminous coal.

*Illinois Central.* — Bituminous coal,  
ordinary hand firing.

*Philadelphia & Reading.* — Bitumi-  
nous coal, standing and running.

*Central of Georgia.* — Bituminous fuel  
at all times, fired by hand only.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Bituminous coal.

*Pennsylvania.* — Not used.

QUESTION 32. — Combustion apparatus  
in the case of liquid fuel? (Please describe  
and attach plan).

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Poto-*  
*mac.* — Blank.

*Illinois Central.* — Blank.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Blank.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Not used.

QUESTION 33. — Grate system: plain or  
rocking grate and method of shaking—hand or  
power?

Answers.

*Baltimore & Ohio.* — We use the box  
type rocking grate with hand shaking  
lever.

*Chesapeake & Ohio.* — Rocking type,  
handpower for shaking.

*Richmond, Fredericksburg & Poto-*  
*mac.* — Rocking type, hand shaker.

*Illinois Central.* — Rocking finger-bar  
grate and shaken by hand.

*Philadelphia & Reading.* — Rocking,  
hand operated.

*Central of Georgia.* — Table grates,  
rocking type, shaken by hand.

*Louisville & Nashville.* — Rocking  
grates, dump grate in front and back  
ends, hand operated.

*Ulster & Delaware.* — Rocking grates,  
dump grates in front and back ends,  
hand operated.

*Pennsylvania.* — Not used.

QUESTION 34. — Number and type of feed  
water apparatus, water gauges, gauge cocks  
and safety appliances?

Answers.

*Baltimore & Ohio.* — Two non-lifting  
injectors are used and, where space is  
available on the back head, a water col-  
umn is placed on the right side with  
a water glass connected thereto, an ad-  
ditional water glass on the left side of  
the back head and three screw thread  
gauge cocks in the water column.

*Chesapeake & Ohio.* — 2 units each  
having:

2 ordinary type lifting injectors and  
boiler checks;

1 ordinary type tubular water glass  
and shield;

3 ordinary type screw thread gauge  
cocks;

1 fusible type low water alarm with  
whistle;

2 ordinary spring type safety valves,  
2 1/2 inches, U. S. safety appliance stan-  
dard.

*Richmond, Fredericksburg & Poto-*  
*mac.* — 2 non-lifting injectors, one W-B  
water column, three gauge cocks.

*Illinois Central.* — 2 lifting injectors, 1 water glass, 3 gauge cocks, No water alarm or other safety appliances.

*Philadelphia & Reading.* — Injector (live steam), 1 bull's eye water glass, 3 compression gauge cocks, 2 spring safety valves.

*Central of Georgia.* — 2 injectors, one water gauge, three gauge cocks and two relief valves.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — 2 lifting injectors, 1 bull's eye water gauge, 3 compression gauge cocks.

*Pennsylvania.* — Not used.

#### Machinery.

QUESTION 35. — Single or double expansion.

#### Answers.

*Baltimore & Ohio.* — We use single expansion locomotive.

*Chesapeake & Ohio.* — Single expansion.

*Richmond, Fredericksburg & Potomac.* — Single expansion.

*Illinois Central.* — Single expansion.

*Philadelphia & Reading.* — Single expansion.

*Central of Georgia.* — Single expansion.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Single expansion.

*Pennsylvania.* — Not used.

QUESTION 36. — Number of cylinders, diameter, stroke and their arrangement?

#### Answers.

*Baltimore & Ohio.* — These are two cylinder locomotives, the Atlantic type

being 22×26 inches and the American 8-wheel, 20×24 inches. The former has outside steam pipes with piston valve cylinders and the latter inside steam pipes with slide valve cylinders.

*Chesapeake & Ohio.* — Two cylinders 18-inch diameter, 26-inch stroke, ordinary arrangement of cast in half saddles and bolted to frames and boiler in the usual manner.

*Richmond, Fredericksburg & Potomac.* — Two cylinders, 21-inch diameter, 26-inch stroke.

*Illinois Central.* — Two cylinders with rods connected to crank pins on outside of wheels. Diameter 18 inches and stroke 25 inches.

*Philadelphia & Reading.* — Two cylinders outside of frame, horizontal, direct connected:

18 1/2×22 inches.

20×22 inches.

19 1/2×22 inches.

*Central of Georgia.* — Two cylinders.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20 class : Two, 19-inch diameter, 26-inch stroke, horizontal outside of frames.

20 class : Two, 20-inch diameter, 26-inch stroke, horizontal outside of frames.

*Pennsylvania.* — Not used.

QUESTION 37. — Valve system.

#### Answers.

*Baltimore & Ohio.* — The Atlantic type has inside admission piston valves and the American 8-wheel, outside admission « D » slide valves.

*Chesapeake & Ohio.* — 1 unit plain « D » slide valves, 1 unit ordinary piston valves.

*Richmond, Fredericksburg & Potomac.* — 10-inch diameter piston valves.

*Illinois Central.* — Slide valves, balanced type.

*Philadelphia & Reading.* — « D » slide valve (balanced).

*Central of Georgia.* — Plain « D » type slide valve.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20 class, saturated — D slide, balanced;  
20 class, superheated — piston;  
30 class, superheated — piston.

*Pennsylvania.* — Not used.

QUESTION 38. — Valve gear?

#### Answers.

*Baltimore & Ohio.* — The Atlantic type has Walschaerts valve gear and the American 8-wheel, Stephenson valve gear.

*Chesapeake & Ohio.* — 1 unit Stephenson, 1 unit Walschaerts.

*Richmond, Fredericksburg & Potomac.* — Walschaerts valve gear.

*Illinois Central.* — Stephenson link motion.

*Philadelphia & Reading.* — Stephenson.

*Central of Georgia.* — Stephenson link motion driven by eccentrics on main driving axles.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Stephenson.

*Pennsylvania.* — Not used.

QUESTION 39. — Method of motion transmission (by rod and crank, chains, etc.).

#### Answers.

*Baltimore & Ohio.* — The transmission is by crank and rod on the Wal-

schaerts geared Atlantic and by eccentric and rod on the Stephenson geared American 8-wheel.

*Chesapeake & Ohio.* — Usual methods of transmission for Stephenson and Walschaerts gears.

*Richmond, Fredericksburg & Potomac.* — Rods.

*Illinois Central.* — Transmission by typical design of connecting rods and pins.

*Philadelphia & Reading.* — Main and side rods.

*Central of Georgia.* — Motion transmission by rod and crank.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Rod and crank.

*Pennsylvania.* — Not used.

QUESTION 40. — Interesting details of motion work, of balance, lubrication, etc.

#### Answers.

*Baltimore & Ohio.* — Motion work equipped with case hardened pins and bushings, lubricated by oil cups and cylinder valves by hydrostatic force feed lubricator.

*Chesapeake & Ohio.* — Nothing unusual.

*Richmond, Fredericksburg & Potomac.* — Motion work equipped with ale-mite pressure system of grease lubrication. Cylinders, piston valves and air pumps lubricated with mechanical force.

*Illinois Central.* — Nothing special in this design but is typical of regular practice as to design, balance and lubrication.

*Philadelphia & Reading.* — Richardson balanced « D » slide valve; hydrostatic cylinder lubricator.

*Central of Georgia.* — No unusual conditions of motion work or balance or lubrication. All of these locomotives are lubricated by hydrostatic lubricators.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Nothing special.

*Pennsylvania.* — Not used.

QUESTION 41. — Drawing of general arrangement, including section views of the engine boiler and accessories on a scale 1/20

if possible. (Please give separately interesting details.)

*Baltimore & Ohio.* — Sent sketches (not reproduced here) of normal superheated *Atlantic* type locomotive (2 units) built in 1910, and normal 4-4 saturated locomotive (7 units) built in 1893.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.*

*Illinois Central.* —

*Baltimore & Ohio :*

Class . . . . .	G-1s.	G-2, G-3.	GE-1.	GE-2, GE-3.	GE-6.	GE-7.
Power plant . . . . .	Single.	Single.	Single.	GE-5. Single.	Single.	Double.
Engine horsepower . . . . .	65	190	250	250	250	300
Revolutions per minute at horsepower rating.	1 300	1 300	1 100	1 100	1 100	1 100
Number of cylinders . . . . .	4	6	6	6	6	6
Cylinder size . . . . .	4 3/4" × 6"	6" × 7"	7 1/4" × 8"	7 1/4" × 8"	7 1/4" × 8"	7 1/2" × 9"
Valves per cylinder . . . . .	2	4	4	4	4	4
General kw. capacity . . . . .	—	—	160	160	160	210
Truck motor horsepower . . . . .	—	—	140	250	250	250
Control end . . . . .	Single.	Single.	Single.	Single.	Double.	Double.
Kind . . . . .	Mechanical.	Mechanical.	Electro- pneumatic.	Electro- pneumatic.	Electro- pneumatic.	Electro- pneumatic.
<i>Transmission.</i>						
Location . . . . .	Body.	Truck.	Body.	Body.	Body.	Body.
Kind of drive . . . . .	Chain.	Gear.	Electric.	Electric.	Electric.	Electric.
Lubrication . . . . .	Force feed.	Pressure.	Pressure.	Pressure.	Pressure.	Pressure.
Water cooling . . . . .	Gear pump.	Gear pump.	Gear pump.	Gear pump.	Gear pump.	Gear pump.
	Rotary pump.	Centrifugal pump.	Centrifugal pump.	Centrifugal pump.	Centrifugal pump.	Centrifugal pump.

*Philadelphia & Reading.* — Sent sketches of three 8-wheeled, saturated steam locomotives not reproduced here.

*Central of Georgia.* — Sent 19 sketches (not reproduced here) of 8-wheeled, saturated steam locomotives built mostly between 1882 and 1892. No special features.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Not used.

QUESTION 42. — Please describe system, mentioning characteristics of motor and accessories, power, number of revolutions balancing, number of cylinders, etc., details of transmission (mechanical, electric, etc.).

Answers.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Gasoline-electric motor car is equipped with two Hall-Scott gasoline engines. These engines are of the four-cycle type and have six cylinders each,

7 1/2 inch diameter, 9-inch stroke. Each gasoline engine is rated at 300 horsepower at 1 100 revolutions per minute. There are two intake and two exhaust valves per cylinder and each engine is equipped with four Zenith carburetors and two Bosch magnetos. A Westinghouse type 181-ampere, 250-kw. generator is direct connected to each gasoline engine and there are four Westinghouse type 559-D-2 traction motors, one connected to each truck axle, three helical gear and pinion. The motors are rated at 295 amperes at 450 volts hourly, 240 amperes, 450 volts continuous. The motor unit develops a tractive effort of approximately 23 000 pounds. Torque governor control is employed and the car is equipped with two 32-volt air compressors at 25 cubic feet capacity per minute each.

*Illinois Central.* — Cars Nos. 113 to 116 — 4 units, 8-cylinder gasoline engine, V type with air starter and electric transmission, 175 horsepower at 550 r. p. m. Generator 8 pole, shunt wound, 80 kw., 600 volts, 550 r. p. m., motor horsepower 100; 600 volts, 550 r. p. m. General Electric Co. 205 "D" gasoline driven air compressors. Motor rated on 75° C. rise allowed. Drum type controller.

Cars 117 to 120 — 4 units, 6-cylinder gasoline engine with electric starter, 190 horsepower at 1 300 r. p. m. and a car speed of 40 miles per hour with engine at 1 000 r. p. m. Car operates at 1 000 r. p. m. normally 5 speeds forward, 1 back — gears in a gear casing — ignition, 2 independent high tension magnetos each firing a separate set of spark plugs. Generator for light, etc., geared 1-1/2 to 1 with engine, 600 watts, voltage regulation, mechanical driven air compressor, Westinghouse type DH-16. Reverse by clutch on driving axle.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — Internal com-

bustion motor. High compression, gasoline motor, 6 cylinders, 100 horsepower at 1 800 r. p. m. Mechanical transmission.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No motors.

*Pennsylvania.* — All four-cycle gasoline engines for both four and six-cylinder types.

QUESTION 43. — Distribution of fuel, possibility of isolating cylinders in case of accident.

Answers.

*Baltimore & Ohio.* — Plain tube type carburetors.

Cars Class G-2, G-3, GE-1, GE-2, GE-3, GE-5 and GE-6 in case of one cylinder is defective, disconnect wires leading to both sparkplugs, remove both intake and exhaust push rods, also wire or block defective valve and come in on five cylinders. For class GE-7 the above will apply, also one engine can be cut out and operated at low speed.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Distribution of fuel is effected through the use of dual vacuum feed systems and four carburetors per engine.

*Illinois Central.* — To each cylinder by manifold; cylinder cannot be isolated in case of accident.

*Philadelphia & Reading.* — Carburetor and intake manifold. No isolation in case of accident.

*Central of Georgia.* — With internal combustion engines the usual conditions would exist with one or more cylinders not functioning. With steam locomotives it is often possible to operate with one cylinder functioning.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Carburetor engines.

QUESTION 44. — Overload possible, for how long?

Answers.

*Baltimore & Ohio.* — Overload possible on Class GE-1, GE-2, GE-3, GE-5 and GE-6, 1150 r. p. m. maximum without load. Can be run continuously.

GE-7, 1200 r. p. m. maximum with load. May be run continuously.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — No records on gas-electric cars as to overload time.

*Philadelphia & Reading.* — Maximum speed of gasoline engines governed by mechanical governor. Output of generators governed by speed of gas engines. Instantaneous overload allowed only in starting. Some engines equipped with torque governor and face plate rheostat control which loads and unloads gas engines automatically by cutting resistance in and out of the main governor field.

*Central of Georgia.* — No electric motors in service.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — We have no established nominal rating.

QUESTION 45. — Please attach designs of whole, with sections, if possible on scale 1/10.

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — See exhibits 13 to 16.

*Illinois Central.*

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — Have no drawings of the internal combustion engine. See answer 41 for steam locomotives.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Have no drawings.

QUESTION 46. — Kindly give sufficient complete data regarding the working while running and while standing or starting and kind of fuel; also give interesting details.

Answers.

*Baltimore & Ohio.* — Gasoline used for all cars. See answer to Question 23.

To start the engine throw the magneto switch to position marked « both » indicating both magnetos firing. Open the throttle lever slightly. If engine is cold, it may be necessary to close choke on carburetor for one revolution. Apply spark lever to full retard position when engine will start. After which release the spark lever. The proper working speed of the engine is approximately 600 revolutions per minute. The mechanical power developed by the engine is converted into electrical energy by the generator which in turn is transmitted through the control apparatus to the electric-driven motors mounted on the drive truck.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — The gasoline electric motor car is started by means of a special series of windings in the main generator which is used as motor when receiving electric current from the storage batteries. After the engines are started the movement of the car is controlled by means of electro-pneumatically operated switches remote controlled with operating levers in

a master controller located convenient to operator's seat in engine cab. The motors are connected in series for starting and are changed over to parallel for speeds above 20 miles per hour. The engine speed is controlled by means of a throttle located in the master controller. Engine cooling is effected by means of roof type radiation air-cooled by forced draft. Gasoline is used for starting and running. The gasoline supply being carried in two 250-gallon tanks which are secured to the underframe of car. The car is arranged for running backward as well as forward and is equipped with continuous automatic train stop and speed control. The gasoline engines are protected with an arrangement whereby the ignition is grounded automatically whenever an automatic brake application is initiated.

*Illinois Central.* — While standing the engines are allowed to idle as at station stops; on both types, gas-electric and direct drive. The direct drive is started on low speed, clutch is thrown out and gears engaged for speeds 2, 3, 4 and 5, as the car speed increases similar to an automobile; car can be operated either speeds 3, 4 or 5 depending on requirements of service. Gas-electric is operated by controller.

*Philadelphia & Reading.* — Starting motors with Bendix drive; also special starting winding on generator which causes generator to turn over as motor to start engine; current obtained from battery for starting. Gasoline is used as fuel. Air compressor operation and battery charging at idling speed and other engine speeds.

*Central of Georgia.* — Motor car engine runs continuously while making stops of short duration. If making long stops, motor is shut off. Starting is by push button which controls electric-starting motor.

Gasoline fuel is used. No unusual de-

tails. Steam locomotive uses bituminous coal as fuel and this fuel is used both when running and standing. When stops of long duration are made, it is necessary to keep fire in good condition.

*Louisville and Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — All are provided with electric starters for the gasoline engines.

QUESTION 47. — c) Weight.

a) Empty?

*Baltimore & Ohio.* — See exhibits Nos. 2 to 10.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.*  
 Front truck . . . . . 87 260 lb.  
 Back truck . . . . . 59 140 lb.  
 146 400 lb.

*Illinois Central.* — No record.

*Philadelphia & Reading.* — Not available.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20 class, saturated :  
 Engine light . . . . . 130 400 lb.  
 Tender — . . . . . 40 300 lb.  
 20 class, superheated :  
 Engine light . . . . . 135 000 lb.  
 Tender — . . . . . 40 300 lb.  
 30 class, superheated :  
 Engine light . . . . . 160 400 lb.  
 Tender — . . . . . 49 400 lb.

*Pennsylvania.* — See Question No. 11.

QUESTION 48. — b) With all accessories, etc.

Answers.

*Baltimore & Ohio.*

G-1 . . . . . 18 150 lb.  
 GE-1 . . . . . 93 200 lb.  
 GE-5 . . . . . 100 900 lb.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.*  
— Blank.

*Illinois Central.*

Nos. 117 to 119 . . . . . 62 180 lb.  
No. 120 . . . . . 62 020 lb.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See answer to Question 47.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

20-class saturated :

Engine and tender . . 241 300 lb.

20-class superheated :

Engine and tender . . 245 900 lb.

30-class superheated :

Engine and tender . . 320 800 lb.

*Pennsylvania.* — Blank.

QUESTION 49. — c) Of rail motors with all accessories and maximum load of passengers and baggage?

#### Answers.

*Baltimore & Ohio.*

G-1s . . . . .	25 000 lb.
GE-1 . . . . .	105 600 lb.
GE-5 . . . . .	120 200 lb.
G-2 . . . . .	67 000 lb.
GE-2 . . . . .	106 400 lb.
GE-6 . . . . .	111 500 lb.
G-3 . . . . .	84 000 lb.
GE-3 . . . . .	107 200 lb.
GE-7 . . . . .	177 100 lb.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.*  
— Blank.

*Illinois Central.*

Nos. 117 to 119 . . . . . 77 010 lb.  
No. 120 . . . . . 72 220 lb.  
Nos. 113 to 116 . . . . . 123 000 lb.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — Car in running condition weighs 32 000 lb.

We have no weight with passengers and baggage. This car has capacity of 29 passengers, seated.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Has never been determined.

QUESTION 50. — If you have rail motors with motor truck detachable from the chasis of the coach, details of how the machine is attached to the coach?

#### Answers.

*Baltimore & Ohio.* — None.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.*  
— Trucks are attached to the car by means of center plates and pin.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — None.

QUESTION 51. — d) Brake system. State wheels to which brakes are applied?

#### Answers.

*Baltimore & Ohio.* — G-1 s, straight air brakes with emergency feature.

G-2, G-3, GE-1, GE-3, GE-5, GE-6, GE-7, automatic air brakes with straight air feature.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.*  
— Brakes are applied to all wheels of motor car.

*Illinois Central.* — To all wheels.

*Philadelphia & Reading.* — All wheels braked.

*Central of Georgia.* — Locomotives have brakes on all driving wheels and all tender wheels operated by air.

Rail car has brakes on all wheels operated by air.

*Louisville & Nashville.* — All wheels.

*Utster & Delaware.* — Air brakes to driving wheels on engine and all wheels on tenders.

*Pennsylvania.* — Air brake on all wheels.

QUESTION 52. — e) System of acoustic signals, whistle, hooter, siren, etc.?

#### Answers.

*Baltimore & Ohio.* — G-1 s, air whistle. G-2, G-3, GE-1, GE-2, GE-3, GE-5, GE-6, GE-7, air horn.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Westinghouse pneumatic horn.

*Illinois Central.* — Horn and whistle.

*Philadelphia & Reading.* — Pneumatic horns, swinging bell or klaxon, air whistle and bell.

*Central of Georgia.* — All locomotives are equipped with Railroad Company's standard steam whistle. Rail car is equipped with Strombos horn, air operated.

*Louisville & Nashville.* — Strombos air operated horn.

*Utster & Delaware.* — Steam whistles.

*Pennsylvania.* — Air operated diaphragm type horn.

QUESTION 53. — f) Sanders.

#### Answers.

*Baltimore & Ohio.* — Class G-1s, G-2, G-3, mechanical air type.

Class GE-1, GE-2, GE-3, GE-5, GE-6, GE-7, electric-pneumatic type.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* Sanders are operated electro-pneumatically.

*Illinois Central.* — Pneumatic with pipe to front and back wheels of motor truck only.

*Philadelphia & Reading.* — Mechanical and air operated on motor truck.

*Central of Georgia.* — All locomotives are equipped with air operated sanders. Pipes carry sand to front and rear of driving wheels. Rail car is equipped with sand boxes operated by lever under control of car operator. Sand is applied to all motor driven wheels.

*Louisville & Nashville.* — Air.

*Utster & Delaware.* — Air and hand.

*Pennsylvania.* — Air operated sander.

QUESTION 54. — g) Draw gear and buffing apparatus. If they are of a special type, please describe.

#### Answers.

*Baltimore & Ohio.* — Standard spring type.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Spring type.

*Illinois Central.* — Not of a special type.

*Philadelphia & Reading.* — Swing automatic coupler. Helical spring draft gear. Helical spring buffer.

*Central of Georgia.* — All locomotives have standard A.R.A. couplers front and rear. Spring draft gear on rear of tenders only.

No special buffers.

Rail car has plain drawbar with pull socket at each end of car.

*Louisville & Nashville.* — Light weight couplers A.R.A. contour. Janney draft gear A.R.A. Class G spring.

*Ulster & Delaware.* — Automatic, with A.R.A. standard head, swivel type each.

*Pennsylvania.* — Automatic couplers with knuckle operated by lever (light design).

QUESTION 55. — h) Heating system (for rail motors).

Answers.

*Baltimore & Ohio.* — G-1s, hot air.  
G-2, G-3, GE-1, GE-2, GE-3, GE-5, GE-6, GE-7, hot water.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* Peter Smith hot water heater and Vapor Car Heating Company's fin type steel radiation.

*Illinois Central.* — Hot water heaters in both types.

*Philadelphia & Reading.* — Hot air on two gas-mechanical motor cars. Hot water on six gas-electric motor cars.

*Central of Georgia.* — Rail car is heated with Peter Smith No. 2 C hot water heater.

*Louisville & Nashville.* — Peter Smith hot water heater.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.* — Hot water with coal as fuel.

QUESTION 56. — i) Lighting.

Answers.

*Baltimore & Ohio.* — Electric, except rear markers, which are oil lamps.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — 32-volt electric for all lights.

*Illinois Central.* — Electric in both types, oil marker lamps, gasoline driven lighting unit on cars 113 and 116.

*Philadelphia & Reading.* — Electric.

*Central of Georgia.* — Locomotive headlights are electric, while the rear lights are oil. The rail car head and rear lights are electric.

*Louisville & Nashville.* — Electric.

*Ulster & Delaware.* — Pyle National turbo-generator, 30-volt, 250-watt lamps, with silvered reflectors for headlights. 10-watt lamps in cab as required by Interstate Commerce Commission rules.

*Pennsylvania.* — Electric.

Item 4. — What is the daily average number of passenger trains, the number of corresponding train-miles and the average frequency of these trains. (Number of passenger-miles. — Number of train-miles.)

QUESTION 57. — a) On little frequented lines?

Answers.

*Baltimore & Ohio.*  
Number of trains . . . . . 26  
Number of train-miles . . . . . 1 060

*Chesapeake & Ohio.*  
Passenger trains . . . . . 2  
Train-miles . . . . . 264.8  
One round trip daily except Sunday.

*Richmond, Fredericksburg & Potomac.*  
— Blank.

*Illinois Central.*

Daily average passenger trains . . . . .	20.2
Daily average passenger train-miles . . . . .	622.5
Daily average frequency of trains . . . . .	1.2

*Philadelphia & Reading.* — Unable to furnish information.

*Central of Georgia.*

Daily average passenger trains . . . . .	30
Daily average train-miles . . . . .	1 043.1

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.*

Daily average passenger trains . . . . .	131
Corresponding train miles per day . . . . .	3 379
Average miles per dispatchment . . . . .	25.8
Mileage per trip varies from 0.9 to 173.6 miles.	

QUESTION 58. — b) On the more important lines.

*Answers.**Baltimore & Ohio.*

Number of trains . . . . .	44
Number of train-miles . . . . .	2 500

*Chesapeake & Ohio.*

Passenger trains : . . . . .	
Train-miles . . . . .	84.6
Two round trips daily except Sunday.	

*Richmond, Fredericksburg & Potomac.*

Local passenger trains per day . . . . .	6
Train-miles per day . . . . .	454
Frequency . . . . .	65"

*Illinois Central.*

Daily average number of passenger trains . . . . .	13.4
Daily average number of passenger train-miles . . . . .	869.6
Daily average frequency . . . . .	1.7

*Philadelphia & Reading.* — Unable to furnish.

*Central of Georgia.*

Daily number of passenger trains . . . . .	34
Daily number of train-miles . . . . .	3 239.9
Average frequency varies from 6 to 12 hours.	
Number of passenger-miles . . . . .	39 265

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.*

4 895 906 passenger-miles. —	229 788
train-miles.	

*Pennsylvania.* — Blank.

QUESTION 59. — c) Altogether.

*Answers.**Baltimore & Ohio.*

Number of trains . . . . .	70
Number of train-miles . . . . .	3 569
Number of passenger-miles . . . . .	22 725
Number of train-miles . . . . .	3 569
equals 6.38.	

*Chesapeake & Ohio.*

Passenger trains . . . . .	6
Train-miles . . . . .	634.0
Three round trips daily except Sunday.	

*Richmond, Fredericksburg & Potomac.*

Local passenger trains . . . . .	6
Train-miles per day . . . . .	454
Average frequency . . . . .	65"

*Illinois Central.*

Daily number of passenger trains . . . . .	17
Daily passenger train-miles . . . . .	1 492.2
Daily average frequency . . . . .	1.6

*Philadelphia & Reading.* — Blank.

*Central of Georgia.*

Daily passenger-trains . . . . .	64
Daily train-miles . . . . .	4 283
Average frequency varies from 3 to 12 hours.	
Number of passenger-miles . . . . .	44 736

*Louisville & Nashville.*  
Number of train-miles . . . 200

*Ulster & Delaware.* — 4 895 906 passenger-miles. — 229 788 train-miles.

*Pennsylvania.* — Same as Question No. 57.

QUESTION 60. — Please indicate the total length of line specified under a, b and c.

Answers.

*Baltimore & Ohio.*

- a) 379 miles.
- b) 869 miles.
- c) 1 248 miles.

*Chesapeake & Ohio.* — 105 miles.

*Illinois Central.* — 287.36 miles.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.*

- a) 255.2.
- b) 856.8.
- c) 1 112.0.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — 128.88.

*Pennsylvania.* — Runs controlled by business requirements and may be a branch or portion of a division or of a branch.

QUESTION 61. — What is the average daily number of passenger trains hauled by the motors mentioned in your reply to question 1 and the number of corresponding train-miles and the average frequency of these trains. Please give information for each class of motor. What do you consider to be the minimum seating capacity necessary for trains on your minor lines?

Answers.

*Baltimore & Ohio.*

Trains . . . 70  
Train-miles . . . 3 569

Seating capacity varies entirely with the local requirements.

*Chesapeake & Ohio.* — No motors cars.

*Richmond, Fredericksburg & Potomac.*

- Two trains per day.
- 118 train-miles per day.
- 75 minimum.
- 120 seating capacity.

*Illinois Central.*

Daily average passenger trains hauled . . . 12  
Daily average passenger motor train-miles . . . 879

*Philadelphia & Reading.*

Average number of daily trains . 71  
Train-miles . . . 663.7  
Average frequency (minutes) . 45

*Central of Georgia.*

Average hauled by motor . . . 6  
Average number of train-miles . 94.7  
Minimum seating capacity . . 25  
Running trips from 3 to 6 hours apart.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — None.

*Pennsylvania.*

Average number of daily passenger trains . . . 131  
Corresponding train mileage per day . . . 3 379

Seating capacity depends on local conditions and is, therefore, variable.

Total space is divided for passengers, baggage and mail, according to the local demand.

QUESTION 62. — What is the average daily number of passenger trains (from a point of view of frequency only) which could be hauled by economical motors of the classes mentioned in reply to your question No. 1 and the number of corresponding train-miles?

Answers.

*Baltimore & Ohio.* — Studies are being made to determine this fact. Entirely dependent upon development in motor car practice.

*Chesapeake & Ohio.* — 6 passenger trains.

316 total train-miles.

*Richmond, Fredericksburg & Potomac.* — All local passenger trains on our line could be handled by gasoline electric motor cars. (See answer to Question No. 4.)

*Illinois Central.* — 12 trains.

*Philadelphia & Reading.* — See answer to Question 63.

*Central of Georgia.* — 24 trains.  
948.4 miles.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — Economy of each operation is developed as business conditions change.

QUESTION 63. — Please say why these trains are not hauled by economical motors?

#### Answers.

*Baltimore & Ohio.* — Will be so hauled as motors are proved acceptable on various runs and justification secured.

*Chesapeake & Ohio.* — With the increase of outside motor bus lines, the revenue from passengers hauled by these trains has gradually decreased and the use of gas-electric or oil-electric motors is now under consideration.

*Richmond, Fredericksburg & Potomac.* — We have suitable light steam locomotives which cannot be used for other service. These will probably be replaced by motors as economical conditions warrant.

*Illinois Central.* — Where light obsolete power unsuitable for main line service is available it is not economical to replace it with motors until it has been worn out.

*Philadelphia & Reading.* — All covered or will be taken care of in very near future.

*Central of Georgia.* — Low cost of coal and high cost of gasoline and gas-electric equipment are the principal reasons.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — To date have found no motor that is practical to operate on our steep grades.

*Pennsylvania.* — See Question No. 62.

QUESTION 64. — Please say the most difficult services performed daily by the motors of various types enumerated in your reply to question N° 1.

#### Answers.

*Baltimore & Ohio.* — No real answer can be made. Motor cars capable of performing service desired are placed on runs so handled. Probably most exacting is a three-car operation (with motor) between Baltimore and Washington.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Only two local passenger trains are operated by gasoline electric motor cars at present. Probably additional motors will be purchased during the coming year if conditions warrant.

*Illinois Central.* — Run between Freeport, Ill., to Dubuque, Iowa, on main line.

*Philadelphia & Reading.* — Run "D" consisting of three round trips between Trenton Junction and Bound Brook, 54.4 miles each, and 2 1/2 round trips between Trenton and Trenton Junction, 4.7 miles each, a total of 181.7 miles.

*Central of Georgia.* — Hauling train by steam locomotive over 17.5 mile-line with maximum grade of 2.76 %, 1 mile long and 2.45 %, 2 miles long, with from 8° to 10° curves.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*New York Central.* — The most difficult rail car runs, with reference to speed, number of stops, schedule and profile are represented by trains 76 and 69 of the St. Lawrence Division, New York Central Railroad.

*Pennsylvania.* — Continuous run of 173.6 miles.

QUESTION 65. — Runs : Miles each run.

Answers.

*Baltimore & Ohio.* — The Baltimore-Washington run is 38.6 miles. Difficulty in speed required and fact that both high-speed express service and slow-speed local service must be given by same equipment.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — 59.4 miles.

*Philadelphia & Reading.* — A. 123.6 miles; B. 81.4 miles; C. 107.5 miles; D. 181.7 miles.

*Central of Georgia.* — 7 runs : 16.5, 17.4, 17.7, 19.6, 38.8, 59.9, 85.3 miles respectively.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — 173.6 miles.

QUESTION 66. — Profile. Distance between stations, grades and their lengths, minimum radius of curves?

Answers.

*Baltimore & Ohio.* — See exhibits 25 to 34, also notes in synopsis.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Average distance between stations about 2 miles.

Maximum grade, 0.8 %, six miles long. Minimum curvature, 2°.

*Illinois Central.* —

*Philadelphia & Reading.* —

*Central of Georgia.* —

*Louisville & Nashville.* — Minimum 4.9 miles to maximum 36.4 miles. 2.75 % grades.

*Ulster & Delaware.* —

*Pennsylvania.* — Average distance between stations 5.4 miles.

*Grades southbound :*

1 grade varying 0.9 to 1.4 %, 3  $\frac{1}{2}$  miles.

1 grade varying 0.9 to 1.46 %, 1  $\frac{1}{2}$  miles.

*Grades northbound :*

1 grade varying 1.17 %, 3/4 mile.

1 grade varying 1.45 %, 1 mile.

Minimum radius of curves 9°0' equals 637 feet radius; 11°24' equals 500 feet radius:

QUESTION 67. — Relation between straight track and curves, difference in altitude, time of trip, average speed, maximum speed and speed on grades?

Answers.

*Baltimore & Ohio.* — See exhibits 25 to 34 and notes in synopsis.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.* — Difference in altitude, 153 feet.

Time of trip, 2 hours 15 minutes south.

Time of trip, 2 hours 10 minutes north.

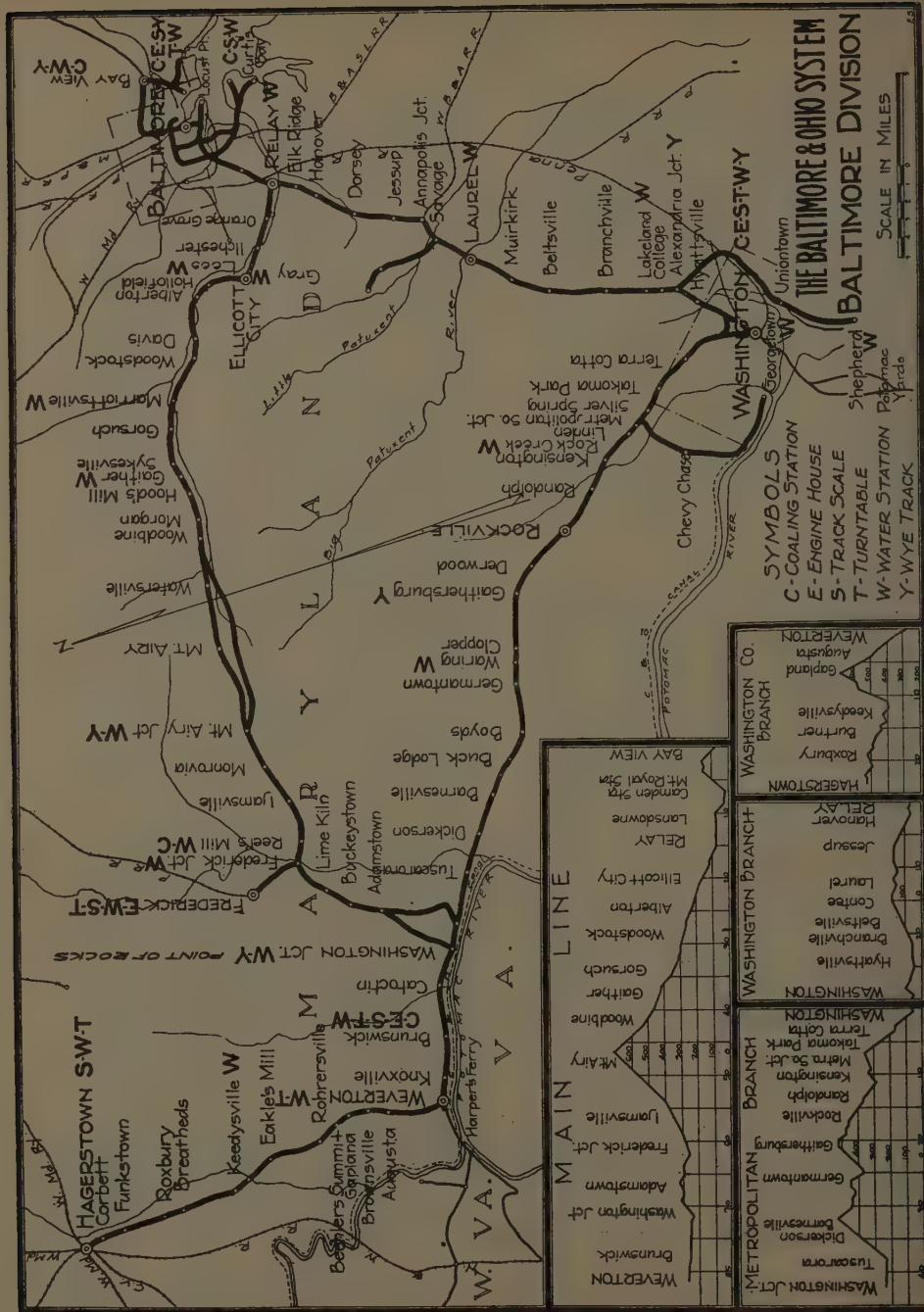
Average speed, 27.5 miles per hour.

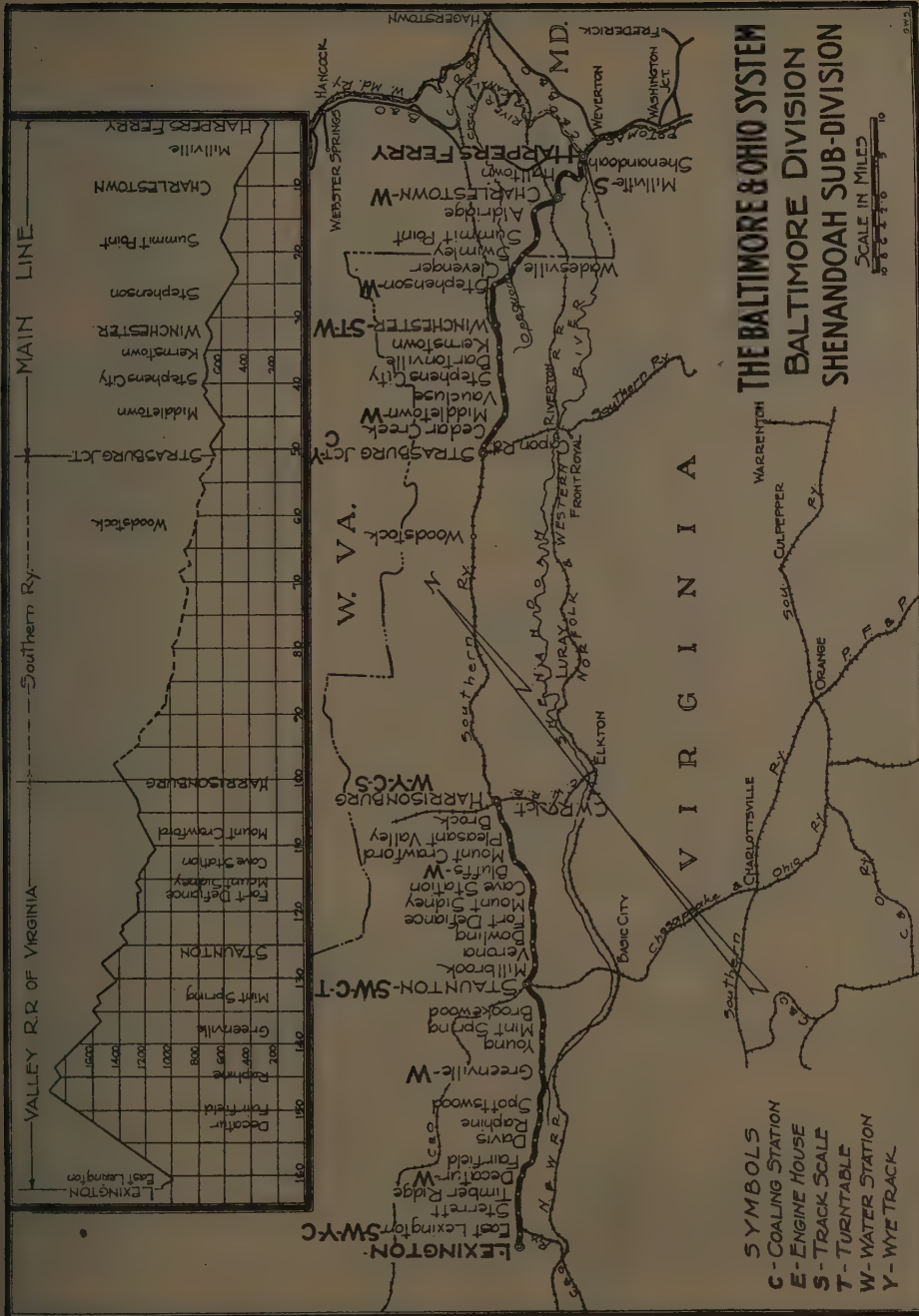
Maximum speed, 65 miles per hour.

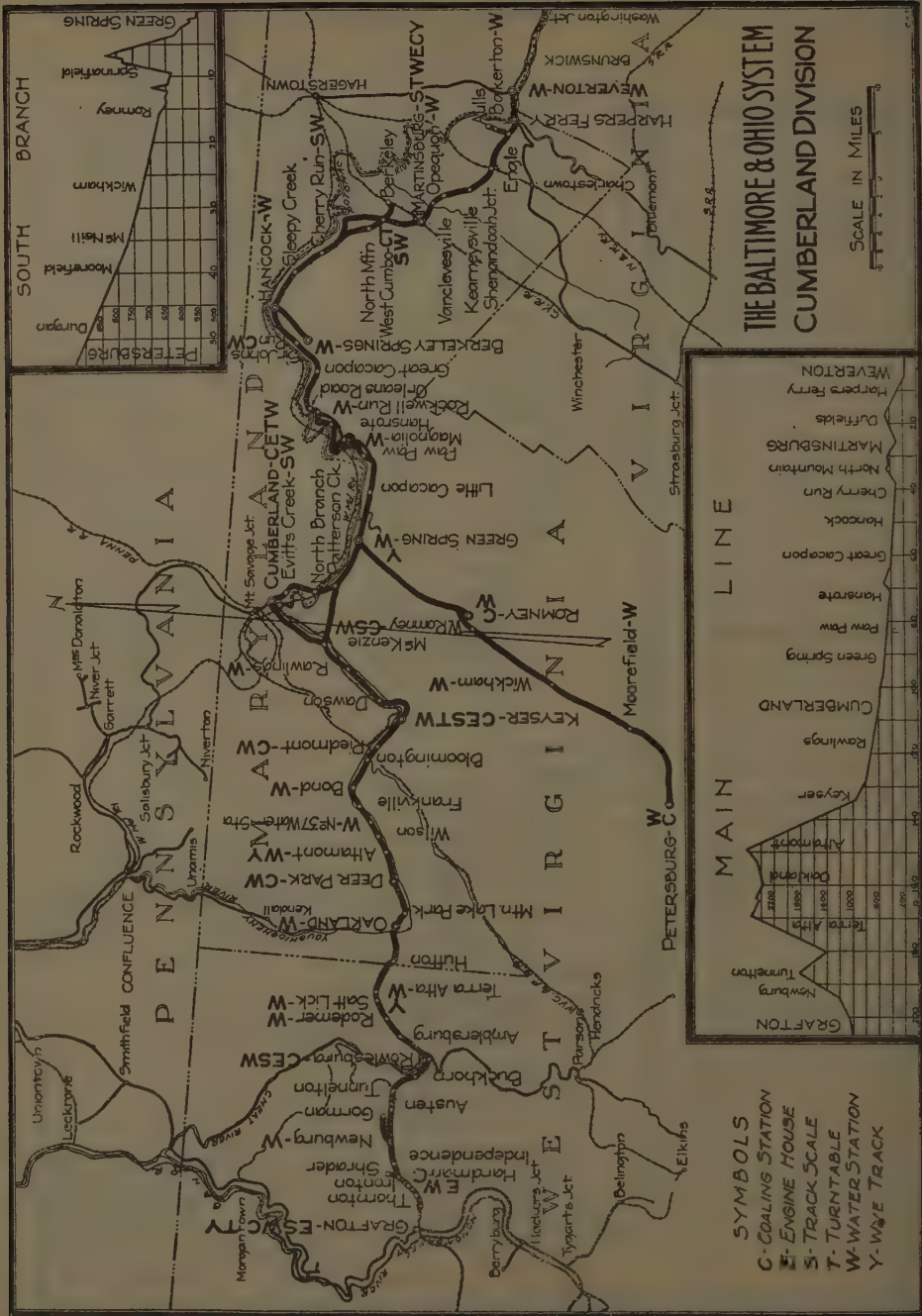
Speed on grades, about 20 to 25 miles per hour.

*Illinois Central.* —

*Philadelphia & Reading.* — Time of trip, Trenton to Trenton Junction, 10 m. Trenton Junction, to Bound Brook, 55 m. Average speed on Trenton







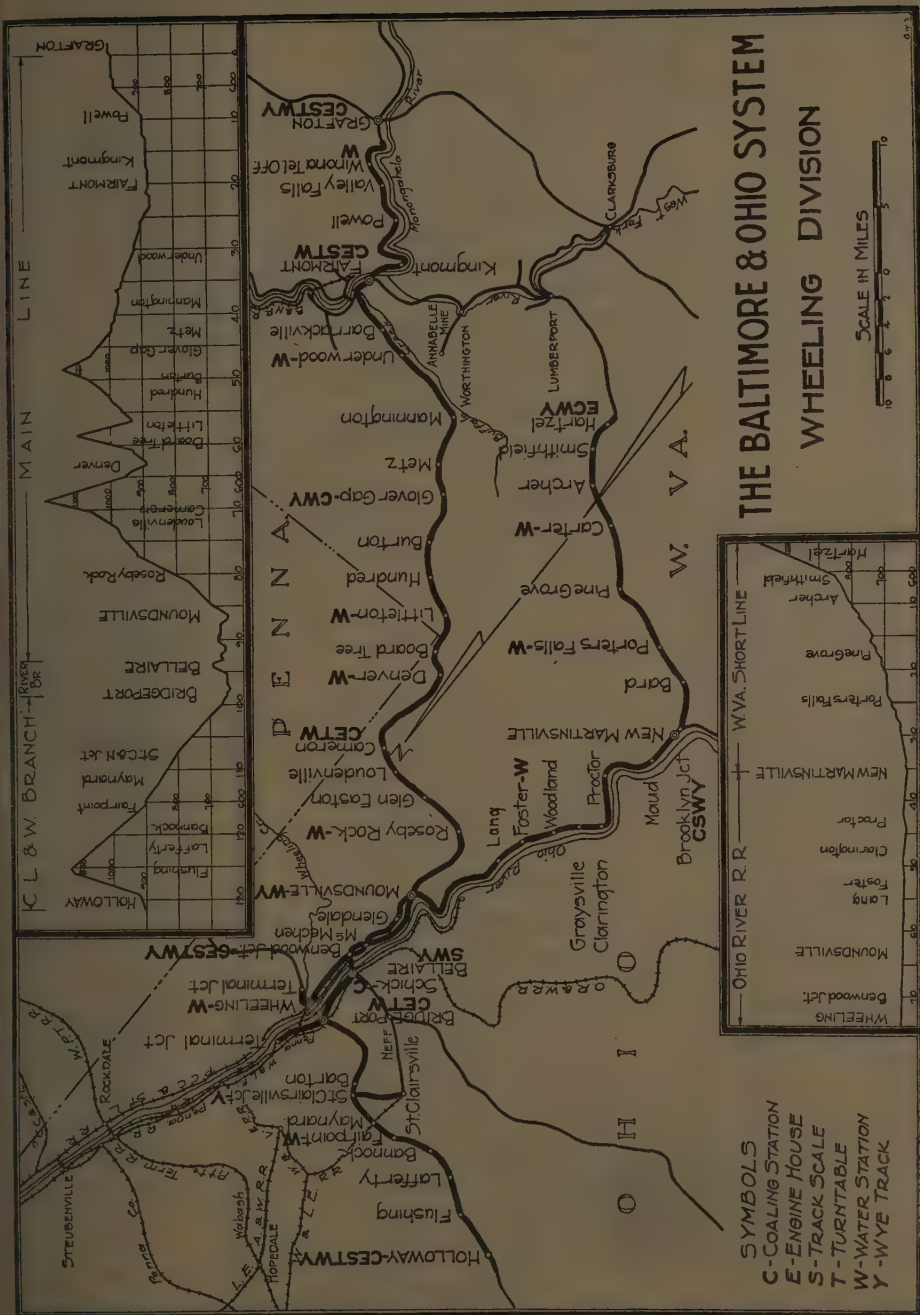
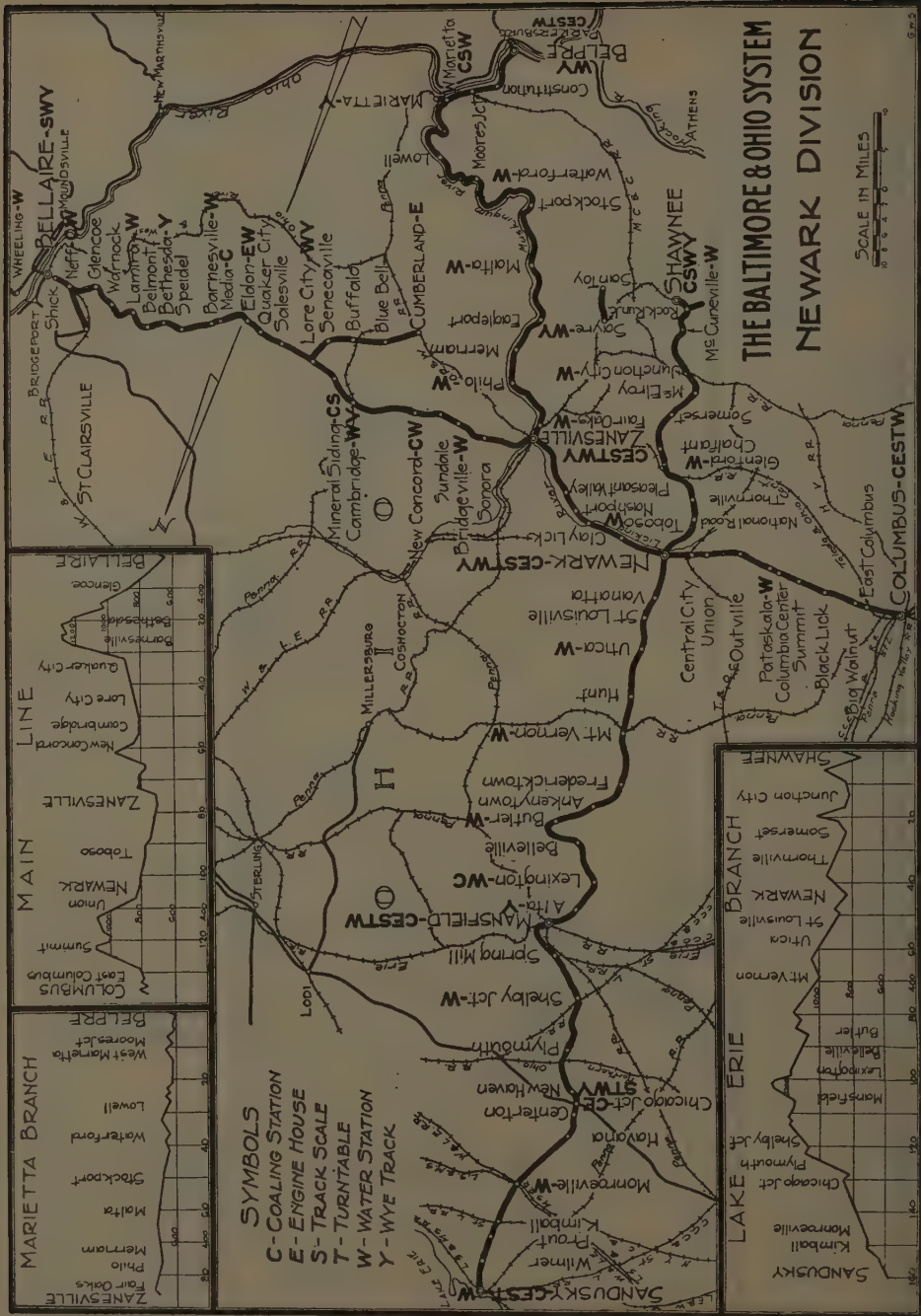


Exhibit 28.









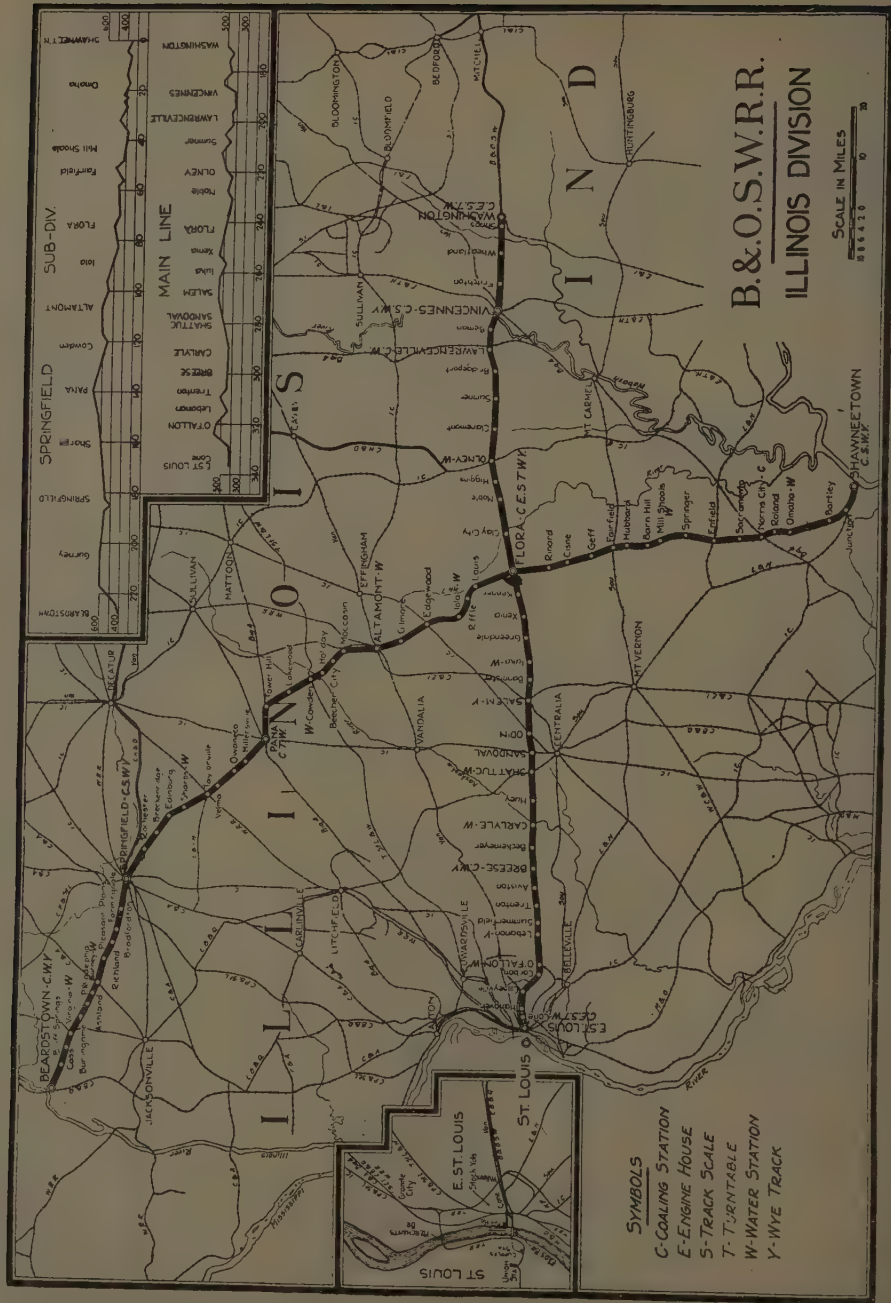


Exhibit 33.

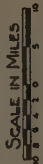
C-COALING STATION  
E-ENGINE HOUSE  
S-TRACK SCALE  
T-TURN TABLE  
W-WATER STATION  
Y-WYE TRACK



A

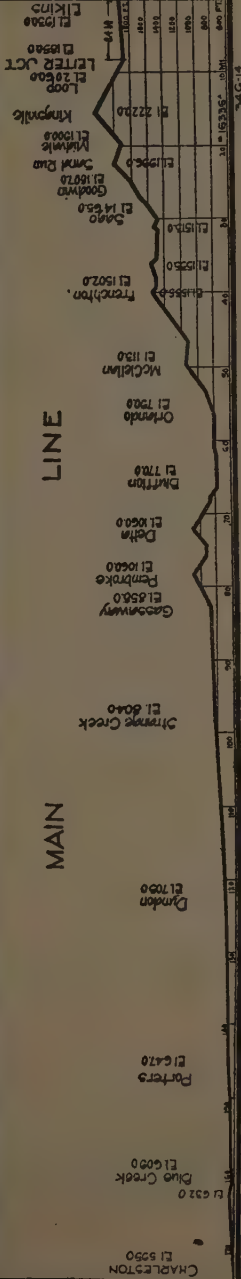
Pateraburg

THE BALTIMORE AND OHIO SYSTEM  
CHARLESTON DIVISION



WZJ

## MAIN



Branch, 22.2 miles. New York Branch, 29.67 miles per hour. Maximum speed, 41 miles per hour. Speed on grade, 25 miles per hour.

*Central of Georgia.* — Difference in altitude varies from 12.4 feet in 18 miles, to 861 feet in 17.4 miles. Time or trips vary from 40 m. for 16.5 miles to 3 h. 45 m. for 85.3 miles.

Average speed, 20 miles per hour for mixed trains, 40 miles per hour for passenger train. Speed on grade will depend on tonnage, but will approximate the average speed.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — 65 % straight. 35 % curves.

Difference in altitude, 2 060 feet.

Average speed, 35 miles per hour. Maximum speed, 50 miles per hour. On heaviest grades, 15 and 20 miles per hour.

*Pennsylvania.* — Straight track approximately 92 %; curves 8 % of total miles. Terminals practically the same altitude.

Time of trip, 6 hours for 173.6 miles equals average speed of 28.9 m. p. h.

Average speed between stations while running 40.5 m. p. h.

QUESTION 68. — Composition and weight of train?

#### Answers.

*Baltimore & Ohio.* — Berkeley Springs-Hancock: one motor car. Washington-Baltimore: one motor car, 2 trailers.

All others, one motor car, one trailer.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Gasoline-electric train consists of one motor unit and one all-steel trailer unit. If conditions warrant, an additional trailer is added.

Motor car weighs 146 400 lb. and the

all-steel trailer weighs 82 600 lb. The additional trailer which is sometimes used is an old wooden coach whose weight is 68 000 lb.

*Illinois Central.* — All trains consist of motor car only except Grenada to Greenwood. One trailer, 183 000 lb. total.

*Philadelphia & Reading.* — Trailer 46 000 lb.

Emergency trailer 66 800 lb.

*Central of Georgia.* — Trains consist of two and three cars and, on unusual occasions, four and five. The cars are mail, baggage, and express and combination 1st- and 2nd-class coach. When extra cars are needed 1st-class coaches are generally required.

Trains vary in weight from 150 000 lb. for 2-car trains to 250 000 lb. for 3-car trains.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.*

Gasoline-electric car 73 feet	
long, 350 horsepower . .	132 000 lb.
1 trailer . . . . .	97 000 lb.
Total . . . . .	229 000 lb.

QUESTION 69. — Is punctuality sufficiently good?

#### Answers.

*Baltimore & Ohio.* — Yes.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Yes.

*Illinois Central.* — Yes.

*Philadelphia & Reading.* — Yes.

*Central of Georgia.* — Yes.

*Louisville & Nashville.* — Yes.

*Ulster & Delaware.* — See Question 68.

*Pennsylvania.* — Yes.

QUESTION 70. — Can you make up lost time?

Answers.

*Baltimore & Ohio.* — Yes.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Yes.

*Illinois Central.* — Yes, under favorable weather conditions.

*Philadelphia & Reading.* — Yes, under favorable weather conditions.

*Central of Georgia.* — Yes, in a limited manner.

*Louisville & Nashville.* — Yes.

*Ulster & Delaware.* — As above No. 68.

*Pennsylvania.* — Yes.

QUESTION 71. — Average number of units effectively utilized daily?

Answers.

*Baltimore & Ohio.* — Twenty-one motor cars.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — One.

*Illinois Central.* — Eight units.

*Philadelphia & Reading.* — Four motor cars and one trailer.

*Central of Georgia.* — Nine steam locomotives. One gasoline rail car.

*Louisville & Nashville.* — Two.

*Ulster & Delaware.* — No motor cars used.

*Pennsylvania.* — 95 % of total number.

QUESTION 72. — Average number of units not used with general indications as to why not used?

Answers.

*Baltimore & Ohio.* — All used.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — None.

*Illinois Central.* — All units in service, except when stopped, at which time they are replaced with small steam locomotives.

*Philadelphia & Reading.* — None in reserve.

*Central of Georgia.* — The units in answer to Question 71 are assigned to these particular lines and when shopping is necessary, other units are assigned in their place.

In some instances extra units are held for extra use or in case of emergency.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — No motors used.

*Pennsylvania.* — 5 % of units held for repairs.

QUESTION 73. — Repairs and replacement.

Answers.

*Baltimore & Ohio.* — Steam trains used when motor cars are repaired.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Motor car placed in service May 1928. Very few repairs or replacements to date.

*Illinois Central.* — Repairs and replacement taken care of by small steam locomotives.

*Philadelphia & Reading.* — General overhaul of gas engines and electrical equipment made every 80 000 miles. No replacements.

*Central of Georgia.* — Repairs are made at regular schedule times, engine being shopped on conditions. Running repairs are made daily. Replacements are made when engines are shopped.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.* — 5 % of annual time.

QUESTION 74. — Do you count on extending the use of the motor cars and by what type ?

Answers.

*Baltimore & Ohio.* — Yes. Gas-electric or Diesels when properly developed.

*Chesapeake & Ohio.* — Considering the advisability of using either gas-electric or oil-electric in lieu of steam locomotives.

*Richmond, Fredericksburg & Potomac.* — Will probably purchase dual engines, gasoline-electric motors.

*Illinois Central.* — Have no general program as yet, but intend to replace steam on the Addison Branch from Chicago to Addison, Ill., a distance of 24.1 miles. We intend to use the gasoline-electric type.

*Philadelphia & Reading.* — Yes. Gas-electric and oil-electric.

*Central of Georgia.* — We will no doubt have to go to more economical means of transportation on these lines and at the present time, the gas-electric rail car has the preference.

*Louisville & Nashville.* — Unnecessary.

*Ulster & Delaware.* — No.

*New York Central.* — It is planned to install additional cars wherever studies of local conditions indicate that it is economically practicable to do so.

*Pennsylvania.* — Yes, when warranted and with electric transmission type.

QUESTION 75. — Please indicate the particular reasons, which influence you in this intention?

Answers.

*Baltimore & Ohio.* — Possible economies which can be secured.

*Chesapeake & Ohio.* — Economical transportation, reduce expenses, and release equipment which can be used to a better advantage and operated more economically in other services.

*Richmond, Fredericksburg & Potomac.* — Can effect a saving of 25 % or more over the cost of steam operation depending, of course, upon the number of train-miles per day.

*Illinois Central.* — The horsepower of the engine in this unit will be about 350 and this is too great for direct drive insofar as they have been developed in the United States. Also there is a greater range of speed with electric transmission and standard electric parts can be used from a manufacturer's stock.

The gasoline motor car is more economical than the steam operated train.

*Philadelphia & Reading.* — Lower net cost of operation.

*Central of Georgia.* — On account of reduction in passenger travel due to privately owned automobiles and autobus lines, the steam trains are now operated at a loss.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — It is the best design to date for handling trailing loads.

QUESTION 76. — Is it undertaken by one man or two?

Answers.

*Baltimore & Ohio.* — One engineman, one conductor, and in most cases a baggageman or flagman.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.* — By one motorman. No fireman or helper is required.

*Illinois Central.* — Handled by one man on each type.

*Philadelphia & Reading.* — One man acting as motorman.

*Central of Georgia.* — Trains handled by steam carry two men on the locomotive and three men for the train.

Rail car carries two men, an operator and a conductor.

*Louisville & Nashville.* — Engineman and conductor.

*Ulster & Delaware.* — Blank.

*New York Central.* — No one man crews are being used. Each crew consists of two and sometimes three men.

*Pennsylvania.* — Not less than two men

QUESTION 77. — Is the number of men subordinate to certain conditions, intercommunication between the driver's cab and the coaches, or the existence of automatic safety appliances, or the existence of automatic feeding apparatus, or use of special fuel, or does the number of the crew vary over the different sections of the line?

Answers.

*Baltimore & Ohio.* — The number of men in the crew is dependent on number of cars in trains, amount of mail, baggage, parcel post and express handled.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — There is intercommunication between the engine room and the balance of the car. The car is also equip-

ped with automatic continuous train stop and speed control. If these features were absent, there would still be no reason or necessity for having an extra engineer or other supplementary help.

*Illinois Central.* — The controls require but one man for their manipulation, and there is intercommunication between driver's cab and the body of the car. The number of the crew does not vary over the runs which are short as indicated in answer to question N° 60.

*Philadelphia & Reading.* — Varies due to local physical condition, and requirements of service, number of trailers in switching required, etc. Original cars did not have automatic safety appliances. New cars equipped with dead man control brake valve.

*Central of Georgia.* — The number of men is governed by agreement between the Railroad Company and each organization and does not vary or change over different sections of the line.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Necessary to have a driver and a conductor to look after passengers, also a baggage man when necessary.

QUESTION 78. — In what capacity are additional crew, if any, employed (drivers or supplementary hands)?

Answers.

*Baltimore & Ohio.* — Supplementary hands.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.* — No additional crew required in the driver's cab. The motor car train employs in addition to the motorman,

one baggage-master, one conductor and one brakeman.

*Illinois Central.* — None employed. (Standard crew consisting of motorman conductor and one trainman.)

*Philadelphia & Reading.* — See answer to question 77.

*Central of Georgia.* — We have no trains or rail cars which are entirely in charge of one man.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See question No 77.

QUESTION 79. — Have you also trains on which the entire control of the train is confined to one man (engineer)? Also indicate the method of issue and collection of tickets.

#### Answers.

*Baltimore & Ohio.* — No.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — No.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — We have no trains or rail cars which are entirely in charge of one man.

*Louisville & Nashville.* — No.

*Ulster & Delaware.* — No.

*Pennsylvania.* — No.

QUESTION 80. — If so, what are the conditions under which such service is authorized?

#### Answers.

*Baltimore & Ohio.* — None.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.* — Blank.

*Illinois Central.* — Blank.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — See answer 79.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — None.

*Pennsylvania.* — No.

QUESTION 81. — What means of security are then taken a) In case of sudden failure of the engineer?

#### Answers.

*Baltimore & Ohio.* — Have no cases where one man comprises the entire crew.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.* — Blank.

*Illinois Central.* — None.

*Philadelphia & Reading.* — On new cars equipped with dead man's feature on brake valve, air brakes will automatically apply, and magnetos on gas engines will be grounded, stopping same.

*Central of Georgia.* — In case of the sudden failure of the engineer, ordinarily some member of the engine or train crew would handle the train to the nearest point where another engineer could be obtained.

*Louisville & Nashville.* — Conductor.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.* — Dead man control feature.

QUESTION 82. — b) In case the automatic brake does not work?

#### Answers.

*Baltimore & Ohio.* — Use the hand brake.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Blank.

*Illinois Central.* — Blank.

*Philadelphia & Reading.* — Hand brake.

*Central of Georgia.* — When the automatic brake fails to work it is necessary to use the hand brake, which is required to be kept in an efficient condition at all times.

*Louisville & Nashville.* — Hand brake.

*Ulster & Delaware.* — Same as 81.

*Pennsylvania.* — Hand brake or with gasoline-electric cars by reversing the motor.

QUESTION 83. — Is it permitted to couple to motor vehicles controlled by one man, other unattended cars?

Answers.

*Baltimore & Ohio.* — Have no one-man controlled cars.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — No.

*Illinois Central.* — No.

*Philadelphia & Reading.* — No.

*Central of Georgia.* — We have no rail motor vehicles under control of one man. We do not haul trailers with highway motor cars and buses.

*Louisville & Nashville.* — No.

*Ulster & Delaware.* — Same as answer to question 81.

*Pennsylvania.* — No one-man cars used.

QUESTION 84. — If so, how many and of what type are these towed cars?

Answers.

*Baltimore & Ohio.* — No such cars.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — No.

*Illinois Central.* — None.

*Philadelphia & Reading.* — Two special gas-electric motor car trailers. — Cars 81 and 82.

*Central of Georgia.* — See answer to 83.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — Same as 81.

*Pennsylvania.* — See question No 83.

QUESTION 85. — Are the conditions of service of crew on trains on minor lines the same as for those on the main lines, particularly as regards working hours, daily and weekly pay. In each case, over how many hours can the daily pay be spread and what should be the interval during which the crew would be unoccupied so that it can be deducted from the pay?

Answers.

*Baltimore & Ohio.* — Standard train and engine-men's rules and rates of pay apply.

*Chesapeake & Ohio.* — The conditions of service of crews on trains on minor lines are not the same as those on main lines.

Minor lines.

Daily pay is made on the basis of 10 hours work within the spread of 10 hours but if 8 hours or more is worked within the spread of 10 hours, intermediate overtime is allowed. Interval

of release to permit considering crew unoccupied must be one hour or more.

Little used trains on more important lines.

Daily pay is based on miles run and overtime applicable based on 20 miles per hour.

*Richmond, Fredericksburg & Potomac.* — The conditions of service of crew on light local passenger trains are the same as others in regard to working hours and pay. Trainmen on short-turnaround passenger runs, no single leg or trip of which exceeds 80 miles, including suburban and branch line service, shall be paid overtime for all time actually on duty or held for duty in excess of 8 hours (computed on each run from time required to report for duty to end of that run), within 10 consecutive hours and also for all time in excess of 10 consecutive hours computed continuously from the first time required to report to final release at the end of the last run. Time shall be counted as continuous service in all cases where the interval of release from duty at any point does not exceed one hour. This rule applies regardless of mileage made.

*Illinois Central.* — The conditions of employment, rates of pay and rules covering working conditions are the same on branch or minor lines as in main line service. The train and enginemen are paid a rate per mile with a guarantee of 100 miles per day's work, except in passenger service for conductors and trainmen where the guarantee is 150 miles per day's work. The overtime basis in passenger service is the same in both main and branch line service, but there are two bases of pay, one is a straight away road and one that is commonly known as short turnaround passenger service. In the first instance, overtime is computed on a speed basis of 20 miles, and all times in excess of

the mileage allowance divided by 20 is considered extra pay. Others more commonly known in railroad parlance as the 8 within 10-hour short turnaround passenger overtime rule. Under the 8 within 10-hour short turnaround passenger overtime rule, where the leg of any trip is 80 miles or less, certain deductions may be made for all off-duty periods of more than one hour at any one point and such time as crews are on duty in excess of 8 hours within the first spread of day work from the time required to report for duty until released at the end of last run is in excess of 10 hours; such excess is also considered and paid as overtime.

*Philadelphia & Reading.* — Conditions of service for minor lines same as on main lines. Hours of service law apply to employees. Crews must be relieved more than one hour on first 10 hours of service to avoid punitive overtime between 8 and 10 hours. No reduction is made in the hours in total spread of service regardless of relief period.

*Central of Georgia.* — Branch lines. — In branch line service where differentials existed in either rates, overtime basis or other conditions of service, the main line rate shall be applied for the service performed. Miles in excess of the mileage constituting a day will be paid pro-rata. If existing rates are higher than the revised main line rates they shall be preserved, but the excess in the rate over the main line rate may be applied against overtime. The passenger or freight overtime basis shall be applied according to the rate paid; other existing conditions of service shall not be affected by the foregoing.

Conductors and trainmen on short turnaround passenger runs; no single trip of which exceeds 80 miles including suburban and branch line service, shall be paid overtime for all time ac-

tually on duty, or held for duty in excess of 8 hours (computed on each run from time required to report for duty at the end of that run), within 10 consecutive hours, and also for all time in excess of 10 consecutive hours computed continuously from the time first required to report for the final release at the end of the last run. Time shall be accounted as continuous service in all cases where the interval of release from duty at any point does not exceed one hour. This rule applies regardless of mileage made.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Yes. Paid overtime after 8 hours, actual service, or a total spread of 10 hours. Can deduct for not less than 1 hour when crew is unoccupied.

*Pennsylvania.* — Basis of pay is for the trip or combination of trips and depends on the length of run or time required, with an established minimum.

No individual is permitted to work in excess of sixteen hours; if he has worked the full sixteen hours, he must be permitted to rest eight hours.

QUESTION 86. — Composition of train hauled by motors in question?

Answers.

*Baltimore & Ohio.* — Most motor trains on Baltimore & Ohio, comprise one motor car and one trailer.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Trains hauled by gasoline-electric motor car usually consist of one motor unit and one trailer. When occasion demands, an additional trailer is added.

*Illinois Central.* — Regular service does not contemplate handling additional cars.

*Philadelphia & Reading.* — Majority of trains consist of motor only. On two round trips a trailer is added.

*Central of Georgia.* — Composition of train hauled by steam locomotive varies to suit conditions. These trains are composed of baggage and mail, second and first class passenger cars.

Rail motor car hauls no additional cars.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No motors.

*Pennsylvania.* — On motor car carrying passengers and baggage, and with the above, one trailer for passenger, mail or express is permitted if business demands it, and provided the power unit is of sufficient capacity.

QUESTION 87. — Number of coaches, weight.

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.*

Number of coaches : One	
weighing . . . . .	99 200 lb.
Number of coaches : One	
weighing . . . . .	120 000 lb.

*Richmond, Fredericksburg & Potomac.*

Steel trailer weighs . . . .	82 680 lb.
Wood trailer weighs . . . .	68 000 lb.

*Illinois Central.* — None.

*Philadelphia & Reading.*

Standard trailer . . . . .	46 000 lb.
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Occasionally a standard combination car weighing 66 800 lb. is applied.

Not more than two trailers applies on any train.

*Central of Georgia.* — Steam trains consist of two to three coaches according to conditions, weight of coaches varies from 53 000 to 95 000 lb.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See question No 68.

QUESTION 88. — Formation of coaches and engine?

Answers.

*Baltimore & Ohio.* — Generally all passenger motor car hauling mail or baggage daily.

*Chesapeake & Ohio.* — Steam engine, baggage and coach.

*Richmond, Fredericksburg & Potomac.* — Motor car is always in lead and wood trailer, when used, is always in the rear.

*Illinois Central.* — Engine, baggage car, coach or coaches.

*Philadelphia & Reading.* — Where standard trailer is used, it is run in the lead in one direction, motorman being able to operate from either motor or trailer. When standard coach is used motor is in all cases run in the lead.

*Central of Georgia.* — This question no doubt refers to the consist of the train. They are made up with one locomotive at the end, next is the baggage and mail, or baggage mail and express car, next is the first and second class combination car, or if a three-car train, there will be a second class car, then the first class car.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — Light steam locomotives not used. See question No. 2.

QUESTION 89. — Number of classes and seats.

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.*

1 unit — 1st class : 62 seats.

1 unit — 1st class : 83 seats.

*Richmond, Fredericksburg & Potomac.* — All seats are first class grade. The usual seating capacity is 120, when the wood trailer is added to the seating capacity, it is increased to 183 seats.

*Illinois Central.* — Average seating capacity of light trailers : 56.

*Philadelphia & Reading.* — All first class. Seats vary from 24 to 50.

*Central of Georgia.* — Passenger cars consist of combination, passenger and baggage, and first and second class passenger and first class passenger coaches. They carry from 24 to 70 seats.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See question No. 88.

QUESTION 90. — Is there intercommunication between the coaches and between the locomotive and adjacent coach?

Answers.

*Baltimore & Ohio.* — Yes.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Yes.

*Illinois Central.* — Use motor cars only and there is intercommunication between them and the trailer coach.

*Philadelphia & Reading.* — Yes.

*Central of Georgia.* — There is intercommunication between the coaches and locomotive by means of the air signal line.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Yes.

*Pennsylvania.* — See question No. 88.

QUESTION 91. — Do you attach trailer cars to rail motors?

Answers.

*Baltimore & Ohio.* — Yes.

*Chesapeake & Ohio.* — No motor cars.

*Richmond, Fredericksburg & Potomac.* — Yes.

*Illinois Central.* — Attach trailer to motor car.

*Philadelphia & Reading.* — Yes, to gas-electric.

*Central of Georgia.* — We do not attach trailer cars to rail motors.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — See question No. 86.

QUESTION 92. — How many?

Answers.

*Baltimore & Ohio.* — One, except between Baltimore and Washington where two are so attached.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — One trailer is usually attached to motor car. If occasion demands, an additional trailer is attached.

*Illinois Central.* — One run only, Grenada to Greenwood, car No. 115.

*Philadelphia & Reading.* — One now. Two to be used later on some of the runs.

*Central of Georgia.* — See answer to 91.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — One.

QUESTION 93. — What is their weight, and the number of seats per class?

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.* — No trailer cars.

*Richmond, Fredericksburg & Potomac.* — All steel trailer weighs 82 680 lb. and seats 80 passengers.

Wooden trailer weighs 68 000 lb. and seats 60 passengers. All seats first class.

*Illinois Central.* — Combination baggage and smoker No. 862, seating capacity 42, weight 98 700 lb.

*Philadelphia & Reading.* — See exhibits 17 to 23. Five others building.

*Central of Georgia.* — See answer to 91.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — See question No. 61.

QUESTION 94. — What influence does such a composition have on speed?

Answers.

*Baltimore & Ohio.* — Schedule must be maintained regardless.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — Motors cars have sufficient power to maintain schedule.

*Illinois Central.* — Reduces the speed.

*Philadelphia & Reading.* — Addition of trailers reduces the speed of train. Gear ratio between motor and axle so proportioned as to give maximum speed called for with trailer operation.

*Central of Georgia.* — See answer to 91.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Reduces the speed that rail motor car can make alone.

QUESTION 95. — Have you any mixed trains?

Answers.

*Baltimore & Ohio.* — No.

*Chesapeake & Ohio.* — Yes, one mixed train.

*Richmond, Fredericksburg & Potomac.* — No.

*Illinois Central.* — Yes.

*Philadelphia & Reading.* — Yes. All handled by steam locomotives.

*Central of Georgia.* — Yes.

*Louisville & Nashville.* — No.

*Ulster & Delaware.* — Yes. In steam service.

*Pennsylvania.* — No.

QUESTION 96. — To what extent?

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — 67 % passenger train cars. 33 % freight train cars.

*Richmond, Fredericksburg & Potomac.* — Blank.

*Illinois Central.* — 55 % of all branch lines.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Mixed trains are operated on four of these lines, there being a total of ten trains. They are all handled by steam locomotives.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — One train each direction daily, except Sunday's on branches. One train each direction daily on the main line.

*Pennsylvania.* — None.

QUESTION 97. — Formation?

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — Passenger train cars are placed next to locomotive and freight train cars at rear of passenger cars.

*Richmond, Fredericksburg & Potomac.* — Blank.

*Illinois Central.* — Engine, freight cars, passenger carrying cars.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Trains are generally made up with the freight cars first, and a car or coach suitable for passengers in the rear.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Blank.

QUESTION 98. — Location of engineer's cab?

Answers.

*Baltimore & Ohio.* — Right hand side engine room. One double end control car has cab on the right hand side both ends.

*Chesapeake & Ohio.* — Operate steam locomotives only, equipped with usual cab arrangement, engineer located on right side of cab.

*Richmond, Fredericksburg & Potomac.* — Engineer's seat is located in engine room which is the front compartment of motor car.

*Illinois Central.* — At right corner, in front, on each type of car.

*Philadelphia & Reading.* — In front right hand corner of motor car.

*Central of Georgia.* — Locomotive with engineer's cab is at the head of the train.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Engineer's location is at the head of the train in the direction that movement is being made.

QUESTION 99. — If there is two of them, give information on their equipment (arrangement for starting, stopping, operation of brakes, signals)?

Answers.

*Baltimore & Ohio.* — None.

*Chesapeake & Ohio.* — Steam locomotives with only one cab.

*Richmond, Fredericksburg & Potomac.* — One only.

*Illinois Central.* — One only.

*Philadelphia & Reading.* — All gas-electric motor cars are equipped with operator's cab at each end with double-end operation. Duplicate control, brake, air and signal equipment. Engine killing switch, operator cab on trailer end of motor car.

Operators cab with all control, air brake and signal equipment on each end of trailer cars for operation with motor car. This installation on trailer cars makes it unnecessary to turn equipment.

*Central of Georgia.* — There is one engineer's cab only.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Same as 98.

*Pennsylvania.* — So far as single units

are concerned, we are now equipping them with control from both ends.

Motor driven cars are not used as double headers.

QUESTION 100. — For motor cars, length of body, sub-divided into compartments, size and other interesting details? (Please attach drawing).

Answers.

*Baltimore & Ohio.* — See exhibits 2 to 10.

*Chesapeake & Ohio.* — Blank.

*Richmond, Fredericksburg & Potomac.*

Engine room : 15 ft. 10 in. long.

Baggage room : 26 ft. 2 in. long.

Smoking compartment : 11 ft. 8 in. long.

Non-smoking compartment : 15 ft. 2 in. long.

See exhibits 13 to 16.

*Illinois Central.* — Blank.

*Philadelphia & Reading.* — See exhibits 17 to 23.

*Central of Georgia.* — See exhibit 24.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — See Question No. 61.

QUESTION 101. — If there are two cabs or two men employed, driving the motor, where do these men take their posts.

Answers.

*Baltimore & Ohio.* — Only one man used, always in cab.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Only one cab and one motor-man.

*Illinois Central.* — One driver only.

*Philadelphia & Reading.* — One operator required.

*Central of Georgia.* — One man drives and one man acts as conductor.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — None.

*Pennsylvania.* — Only one man used.

QUESTION 102. — If only one driver, where is he located?

Answers.

*Baltimore & Ohio.* — In cab, right hand side front on car. Engine room.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Motorman is located in the engine room.

*Illinois Central.* — In cab at right front corner of motor car on each type.

*Philadelphia & Reading.* — In operator's cab front end, right hand facing direction of movement.

*Central of Georgia.* — Located at head end of car.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See Questions Nos. 98 and 99.

QUESTION 103. — Is the speed identical in both directions in which the motor travels.

Answers.

*Baltimore & Ohio.* — Yes.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Motor car train usually operated in forward direction only. It is possible for operator to back same, and the

speed in each direction is the same if it were not for the automatic train control which limits the speed to the maximum of 25 miles per hour when the train is operated backward.

*Illinois Central.* — Motor cars are turned at each terminal as they are equipped with but single end control.

*Philadelphia & Reading.* — Yes.

*Central of Georgia.* — Yes.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Yes.

QUESTION 104. — Information on the flexibility of the motor?

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — It is possible to operate car with one engine and generator and two traction motors idle. With series connections motor, car can operate successfully on light switching work. With parallel connection, a speed in excess of 5 to 65 miles per hour can be obtained on level tangent track.

*Illinois Central.* — Can be adjusted for variations in load and speed.

*Philadelphia & Reading.* — Usual characteristic of gasoline engines with an idling and working engine speed.

*Central of Georgia.* — Motors connecting to driving axle through shaft, to auxiliary transmission with two universal joints. Shafts from auxiliary to driving axles are equipped with universal joints each.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Nothing to report.

*Pennsylvania.* — Both prime mover and traction motors are of the variable speed type.

QUESTION 105. — In case of rush of passengers are you able to increase the load of the train?

Answers.

*Baltimore & Ohio.* — Only to limit of capacity of train.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Yes.

*Illinois Central.* — No. Have no rush equal to overload.

*Philadelphia & Reading.* — Yes, within reasonable limit.

*Central of Georgia.* — Yes.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*New York Central.* — The class of car, seating capacity, power plant equipment and number of cars used are governed by the local conditions to be met. The cars are of sufficient size and capacity to handle average traffic period. Exceedingly heavy traffic during holiday periods is handled by steam equipment.

*Pennsylvania.* — Yes, either by permitting passengers to stand or adding one trailer as per question No. 86.

QUESTION 106. — Within what limits?

Answers.

*Baltimore & Ohio.* — No additional trailers can be hauled on any runs, over those now assigned.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Motor car has sufficient power to maintain schedules when hauling two trailers.

*Illinois Central.* — None.

*Philadelphia & Reading.* — Each motor can handle a light weight trailer in addition to the regular consist.

*Central of Georgia.* — The limit is the capacity of the motor car. No additional cars are added to motor car. Steam trains can have cars added to suit requirements.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Same as 105.

*Pennsylvania.* — See question No. 105.

QUESTION 107. — With what effect as regards speed?

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Very little.

*Illinois Central.* — See answer to 105.

*Philadelphia & Reading.* — Local conditions too variable to allow definite answer.

*Central of Georgia.* — Speed of steam train would be affected in proportion to number of cars added. Very seldom is the capacity of the locomotive reached unless there is some unusual movement.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — Same as 105.

*Pennsylvania.* — See question No. 94.

QUESTION 108. — Or do you have recourse to ordinary locomotives?

Answers.

*Baltimore & Ohio.* — Substitute steam trains when movement is abnormal.

*Chesapeake & Ohio.* — Only use steam locomotives.

*Richmond, Fredericksburg & Potomac.* — Not necessary.

*Illinois Central.* — We have to use steam locomotives.

*Philadelphia & Reading.* — We have to use steam locomotives.

*Central of Georgia.* — Steam locomotives and trains could be resorted to if motor car was not of sufficient capacity.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Same as 105.

*Pennsylvania.* — Unusual conditions, such as county fairs, circuses, etc., arranged for ahead of time by use of suitable steam locomotive and regular passenger car equipment.

QUESTION 100. — Is a limit of capacity, all things taken into account, to be considered as an inconvenience?

#### Answers.

*Baltimore & Ohio.* — Substitute steam trains when movement is abnormal.

*Chesapeake & Ohio.* — No. Practically all of the time the equipment used meets the requirements.

*Richmond, Fredericksburg & Potomac.* — Have not found it so.

*Illinois Central.* — Not under Illinois Central Railroad Company operating conditions, where peak capacity is provided for; ordinarily it would be an inconvenience.

*Philadelphia & Reading.* — Any limit may be an inconvenience but must be endured at times in interest of Company.

*Central of Georgia.* — Yes.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Same as 105.

*Pennsylvania.* — These conditions are considered when determining the suitability of steam locomotives or motor driven cars.

QUESTION 110. — Locomotives with internal combustion motors, etc. and motor cars. Do you store them the same as steam locomotives, in roundhouses or have you special buildings for them?— Reasons?

#### Answers.

*Baltimore & Ohio.* — Generally kept in separate part of roundhouse when placed therein.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Do not find it necessary to send motor car to roundhouse at end of the run. The car is stored outdoors, when not in use, at coach yard, and is handled in a manner similar to passenger cars.

*Illinois Central.* — Store them in roundhouse with steam locomotives to save the expense of special building and occasionally they are not housed but cared for outside.

*Philadelphia & Reading.* — Where no engine house facilities are available, car shelters are constructed. Stored in roundhouses the same as locomotives.

*Central of Georgia.* — One motor rail car now in use runs 16.5 miles and there has been no provision made for housing it. Do not think it necessary to build two houses to store this car over night.

*Louisville & Nashville.* — Roundhouse.

*Ulster & Delaware.* — No motor equipment.

*New York Central.* — Cars are stored at stations or engine houses, depending upon facilities available. Maintenance work is handled by mechanics picked from regular enginehouse forces.

*Pennsylvania.* — Stored same as steam locomotives.

QUESTION 111. — Are they attended by special mechanics or by mechanics who deal with ordinary locomotives?

Answers.

*Baltimore & Ohio.* — By ordinary railroad mechanics.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Ordinary shop mechanics tend to the inspection and repairs to motor cars.

*Illinois Central.* — By mechanics who deal with ordinary steam locomotives.

*Philadelphia & Reading.* — Cars maintained by locomotive mechanics who are instructed in this special work.

*Central of Georgia.* — Attended to by regular mechanics who are used for locomotives and cars.

*Louisville & Nashville.* — Ordinary mechanics.

*Ulster & Delaware.* — No motors.

*Pennsylvania.* — Not attended by special mechanics.

QUESTION 112. — Maximum distance that can be run on regular services, taking into account supplies and conditions of the fire?

Answers.

*Baltimore & Ohio.* — Have no record. Performance shows cars make from 1 to 5 miles per gallon of gasoline, de-

pending upon operating conditions and service. Maximum run depends upon this and size of gasoline tank.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — The maximum distance our motor can run on a regular schedule is 113.5 miles. The car, however, carries sufficient gasoline and supplies to make a run of about 400 miles.

*Illinois Central.* — Maximum length of assigned run of steam engine in passenger service is 455 miles.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — No data available.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Blank.

QUESTION 113. — Maximum speed on level track under satisfactory conditions of stability and smoothness of running, and with regular running of the motor?

Answers.

*Baltimore & Ohio.* — 40 to 65 miles per hour, dependent upon size and character of power in cars.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — About 65 miles per hour. Speed control governor set to apply air brakes if this speed is exceeded. Without train control, the car is capable of obtaining a speed of nearly 70 miles per hour.

*Illinois Central.* — About 50 miles per hour and runs smoothly.

*Philadelphia & Reading.* — 50 to 60 miles per hour.

*Central of Georgia.* — We have speed limits on all of these lines. Rail motor car has a limit of 30 miles per hour. Mixed trains 20 miles per hour, and passenger trains 40 to 50 miles per hour.

*Louisville & Nashville.* — 60 miles per hour.

*Ulster & Delaware.* — No motors.

*Pennsylvania.* — With unit operating alone, a speed of 70 miles per hour can be attained with safety, the same as with heavy steam passenger locomotives.

This speed will be reduced when trailer is attached.

QUESTION 114. — What difficulties have you met from the point of view of maintenance?

#### Answers.

*Baltimore & Ohio.* — None.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — None. Motor car easily maintained up to this time.

*Illinois Central.* — No difficulty other than getting material on short notice for engines and electric apparatus.

*Philadelphia & Reading.* — No particular difficulties met from maintenance standpoint except trouble experienced with exhaust gaskets and manifolds burning out due to grade of gasoline originally used.

*Central of Georgia.* — Rail motor car has not been in service long enough to get any data or form any opinion as to maintenance. Have not met any difficulties in maintenance of our locomotives and cars.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No motor cars.

*Pennsylvania.* — Only such difficulties as arise in the development of any new mechanism.

QUESTION 115. — Difficulties in connection with quality of water?

#### Answers.

*Baltimore & Ohio.* — On certain divisions treated water is used.

*Chesapeake & Ohio.* — No difficulties on account of using treated water from water softener plants.

*Richmond, Fredericksburg & Potomac.* — None.

*Illinois Central.* — No difficulties.

*Philadelphia & Reading.* — No difficulties experienced with quality of water used in motor car.

*Central of Georgia.* — Have no difficulties with water, all water, with a few exceptions, being fair boiler water and such as is not, is treated chemically.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Scale forming water requires more attention to piping and passages and more frequent cleaning of cooling system.

QUESTION 116. — Public attitude to light trains, rail motors, etc.?

#### Answers.

*Baltimore & Ohio.* — Favorable.

*Chesapeake & Ohio.* — No complaints. Have ample equipment to serve the public.

*Richmond, Fredericksburg & Potomac.* — Appears to be favorable.

*Illinois Central.* — Favorable.

*Philadelphia & Reading.* — No objections, except where schedule revisions

require them to change cars at junction points where they formerly enjoyed their through service.

*Central of Georgia.* — Experience is that the public attitude in regard to light trains, rail motors and buses is favorable; in the case of the one rail car and one highway bus which have been installed, these have been received favorably.

*Louisville & Nashville.* — Favorable.

*Ulster & Delaware.* — Believe the public attitude would be favorable.

*Pennsylvania.* — Generally satisfactory.

QUESTION 117. — Average consumption of fuel including that for lighting and consumption when stationary, and also separately?

#### Answers.

##### *Baltimore & Ohio.*

Brill 75 gasoline car (190 H. P.), 4 miles per gallon in one case, and, Brill 75 gasoline car (190 H. P.), 2 miles per gallon in one case.

Edwards gasoline car (65 H. P.), 4.2 miles per gallon, and Brill 600 electrics (250 H. P.), 1.5 to 20 miles per gallon dependent upon operating conditions.

Standard steel gas-electric (600 H. P.), 1.5 miles per gallon, estimated; in service too short period to give definite figure.

*Chesapeake & Ohio.* — Locomotive fuel consumption, including stationary portion.

21.8 per passenger car-mile.

80.5 per locomotive-mile.

None used for lighting.

*Richmond, Fredericksburg & Potomac.* — Average consumption of gasoline is about 1.2 gallons per mile on

schedules requiring an average of one stop every 2 miles and of sufficient speed to require use of both gasoline engines. These figure includes about 3 gallons per round trip used for testing train control and other mechanical and electrical apparatus on motor car at end of run.

*Illinois Central.* — Do not have fuel consumption except as to operation of entire car or train and no record for consumption while stationary. Train miles per gallon of gasoline :

117 : 2.82	113 : 1.85
118 : 3.44	116 : 2.21
119 : 3.45	114 : 2.21
120 : 3.70	115 : 1.86

13.41	8.13
-------	------

Average : 3.35                      Average : 2.3 miles  
per gallon.

*Philadelphia & Reading.* — Average miles per gallon of gasoline 1.47 based on 250-H. P. gas-electric cars (one engine). 350-H. P. gas-electric cars, average 1.15 miles per gallon (two engines).

*Central of Georgia.* — Our locomotive fuel varies from 22 to 30 lb. of coal per passenger train car-mile according to road and service. We have no data on cost of gasoline for rail motor car per mile as yet. The above figures include all fuel put on the locomotive tender and includes firing up, stand-by losses, lighting locomotive and train as well as heating.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — No data available.

*New York Central.* — Fuel performance in accordance with profile, speed and number of stops and average figure for the gas-mechanical motor car operating without trailer is 2.5 miles per gallon and for the gasoline-electric cars,

which, are heavier, is 1.6 miles per gallon.

*Pennsylvania.* — Consumption varies from 1 mile per gallon of gasoline for larger cars with trailer to 6 miles per gallon for light cars.

QUESTION 118. — Average cost per train-mile and per ton mile for : a) fuel (or electric power).

#### Answers.

*Baltimore & Ohio.* — Average cost per train mile is 6.82 cents.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Gasoline fuel is 0.16 lb. per train-mile.

*Illinois Central.* — Do not have it for ton miles as this covers motor car operation in passenger service.

Average cost for gasoline fuel per train-mile from January 1st to October 1st 1928 for eight cars was 4 3/4 cents.

*Philadelphia & Reading.* — Average cost for fuel per train-mile is 0.37486; per ton-mile is 0.00074.

Average cost of gasoline per train-mile 7.83 cents, based on 250-H. P. gas-electric cars. Other figures not available at present.

*Central of Georgia.* — Average cost of fuel per passenger train-mile is 11.4 cents.

Average cost per train-mile, freight, 30.16 cents, including locomotive and tender.

Average cost per train-mile, freight, 0.0187 cent excluding locomotive and tender. No electric power used.

*Louisville & Nashville.* — 32 cents per train-mile.

*Ulster & Delaware.* — Same as 117.

Large cars (gasoline-electric) cost \$0.15 per train-mile.

Light cars (gasoline) cost \$0.25 per train-mile.

Large cars cost \$0.0013 per ton-mile.

Light cars cost \$0.0017 per ton-mile.

QUESTION 119. — b) Lubrication material.

#### Answers.

*Baltimore & Ohio.* — Average cost of train-mile for lubrication is 0.49 cent.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Lubricating oil 0.006 cent per train-mile.

*Illinois Central.* — Average cost per train-mile, 1 January to 31 October 1928, for 8 cars was 0.812 cent.

*Philadelphia & Reading.* — Average cost of lubrication per train-mile is 0.00456 cent and per ton-mile, 0.000009 cent.

Average cost of lubricating oil per train-mile, 0.00607, based on 250-H. P. gas-electric cars. Other figures not available at present.

*Central of Georgia.* — Average cost per passenger train-mile 0.006 dollar.

Average cost per ton mile, freight, 0.000004 dollar, including locomotive and tender. Average cost per ton-mile freight, 0.000095 dollar, excluding locomotive and tender.

*Louisville & Nashville.* — 0.0325 cent. per train-mile.

*Ulster & Delaware.* — Same as 117.

*Pennsylvania.* — \$0.002 per train-mile.

QUESTION 120. — c) Lighting.

#### Answers.

*Baltimore & Ohio.* — Included in 118.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.*

— Electric power for lighting is furnished by main engine and generator units. Cannot separate cost for lighting.

*Illinois Central.* — No records as this cost was included in answer to No. 118.

*Philadelphia & Reading.* — Data not kept separately, included in No. 118 and No. 119.

*Central of Georgia.* — Average cost per passenger train-mile 0.009 cent.

*Louisville & Nashville.* — Included in a) No. 118.

*Ulster & Delaware.* — Same as 117.

*Pennsylvania.* — Cost is included under fuel, Question No. 118.

QUESTION 121. — d) Water.

Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Only a few gallons of water required monthly for engine cooling. The cost is negligible.

*Illinois Central.* — No record.

*Philadelphia & Reading.* — Average cost of water per train-mile, 0.01571 cent; per ton-mile, 0.00003 cent. Not kept separately for gas-electric cars, included in Nos. 118 and 119.

*Central of Georgia.* — Average cost per passenger train-mile 0.008 dollar.

Average cost per ton-mile, freight 0.000011 dollar, including locomotive and tender. Average cost per ton-mile, freight, 0.000013 dollar, excluding locomotive and tender.

*Louisville & Nashville.* — No record.

*Ulster & Delaware.* — Same as 117.

*Pennsylvania.* — Practically nothing per train-mile as cost per 1 000 gallons is from 5 to 12 cents.

QUESTION 122. — e) Please state price per unit of materials, motorman and train crew. Enumerate.

Answers.

*Baltimore & Ohio.* — Average cost of crew: motorman, conductor and flagman, and in one case a baggageman, is, per train-mile, 18.78 cents.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Motorman, \$ 11.84 per round trip. Conductor, \$10.76 per round trip. Baggagemaster, \$8.08 per round trip. Brakeman, \$7.35 per round trip.

The conductor, baggagemaster and brakeman are paid on a guarantee of 30 working days per month basis and if the schedule on which the motor car operates does not require its use during 30 days of each month, the conductor, baggagemaster and brakeman are paid an additional sum of \$7.20, \$5.22, and \$5.05 respectively per day of those days on which the motor car schedule does not require its operation.

*Illinois Central.* — Conductor 0.476 cent per mile and based on 150 miles.

Trainmen, 0.345 cent per mile and based on 150 miles. Motorman, 0.650 cent per mile and based on 150 miles.

*Philadelphia & Reading.* — Motorman, \$7.53, 10 hours or 160 miles.

Conductor, \$7.50, 10 hours or 150 miles. Baggageman, \$5.52, 10 hours or 150 miles.

Baggagemaster also acts as flagman.

*Central of Georgia.* — Blank.

*Louisville & Nashville.* — Motorman, 0.087 cent per mile. Conductor, 0.077 cent per mile.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See Question No. 85 as to the basis of pay. The hourly or mileage rates are the same as the minimum paid in steam passenger service.

QUESTION 123. — f) Cleaning and maintenance of mechanical and electric parts of machine?

**Answers.**

*Baltimore & Ohio.* — Average cost of maintenance of motors is per train-mile 3.7 cents.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Maintenance and inspection of electrical and mechanical parts of machine including air brakes amounts to about \$0.06 per train-mile. Maintenance and inspection of automatic train control amounts to about \$0.006 per train-mile.

*Illinois Central.* — Machinists make 75 cents per hour. Electricians, 75 cents per hour, helpers, 52 cents per hour, wipers, 38 cents per hour.

*Philadelphia & Reading.* — No fixed price. All day-rate.

Rates :

Machinists . . . 77 cents per hour.  
Electricians . . . 77 — — —

*Central of Georgia.* — Mechanical and electrical parts are cleaned by regular cleaners who are paid from 22 to 25 cents per hour.

Maintenance of mechanical and electrical parts will be by regular mechanics and electricians and specialists at from 52 to 75 cents per hour.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Cleaning and maintenance of gasoline-electric cars \$ 0.09 per mile.

Cleaning and maintenance of gasoline cars \$0.122 per mile.

QUESTION 124. — g) Cleaning and maintenance of coach portion, if there are expenses additional to those for ordinary coaches?

**Answers.**

*Baltimore & Ohio.* — Average cost of

maintenance of cars and trailers per train-mile is 1.39 cents.

Average cost of miscellaneous supplies etc. is, per train-mile, 3.41 cents.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — No difference from ordinary coaches.

*Illinois Central.* — Car cleaners, 38 cents per hour.

*Philadelphia & Reading.* — Nothing to report.

*Central of Georgia.* — Cleaning of coach portion of rail car will be done by coach cleaners at 17 cents per hour for women and 25 cents per hour for men.

Maintenance by car specialists and car mechanics at 52 to 75 cents per hour. There are no additional expenses to those for regular coaches.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — Included in costs given in Question No. 123.

QUESTION 125. — Same information as above (except g) in the case where an ordinary locomotive is used which is economically best appropriated to the trains in question?

**Answers.**

*Baltimore & Ohio.* — The average cost of steam operation covering general expenses, operation and maintenance, minimum \$0.69, maximum \$0.179.

*Chesapeake & Ohio.*

Fuel . . . 0.09723, locomotives.  
Lubrication . . 0.00464, locomotive and passenger cars.  
Lighting . . . 0.01203, passenger cars.  
Water . . . 0.00787, locomotives and passenger cars.  
Cleaning . . . 0.05853, passenger cars.

*Richmond, Fredericksburg & Potomac.*

— For steam operation on local passenger trains.

Cost of fuel per train-mile, 0.27.

Cost of water per train-mile, 0.007.

Wages, engineman per round trip \$13.15.

Wages, fireman per round trip \$10.10.

Other costs the same as for motor car.

#### *Illinois Central.*

Skilled mechanics . . .	0.75	per hour.
Helpers all trades . . .	0.52	— —
Hostler . . . . .	0.703	— —
Cinder pit men . . . .	0.395	— —
Wipers . . . . .	0.38	— —

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Ordinary steam locomotives where used are handled by the same class of cleaners that is 22 to 25 cents per hour and specialists and mechanics from 52 to 75 cents per hour.

*Louisville & Nashville.* — Blank.

#### *Ulster & Delaware.*

Engineman . . . . .	\$ 6.00	per day.
Fireman . . . . .	4.48	— —
Baggage man . . . . .	4.56	— —
Flagman . . . . .	4.40	— —
Conductor . . . . .	6.40	— —

Locomotive maintenance cost, 20 cents per mile.

#### *Pennsylvania.*

	Cleaning.	Main-	Total.
	\$	\$	\$
Standard locomotive, cost per mile . . .	0.01	0.27	0.28
Standard passenger car, cost per mile . . .	0.0072	0.0228	0.03

The cost per mile, therefore, for a steam train would be \$0.28 for locomotive plus \$0.03 time the number of passenger cars used in the train.

QUESTION 126. — Average purchase price of economical motors, enumerated, expressed in terms of a stable currency; time of depreciation to be expected?

Answers.

#### *Baltimore & Ohio.*

G-1 . . . . .	\$ 9 320.00
G-2 . . . . .	26 878.50
G-3 . . . . .	26 878.50
GE-1 . . . . .	39 347.00
GE-2 . . . . .	41 414.00
GE-3 . . . . .	43 211.08
GE-5 . . . . .	45 733.90
GE-6 . . . . .	45 415.00
GE-7 . . . . .	65 718.00

*Chesapeake & Ohio.* — No motors.

#### *Richmond, Fredericksburg & Potomac.*

— Motor unit with dual 300-H. P. engine and necessary electrical equipment cost \$70 000.00. We allow a rate of 10 % depreciation for mechanical and electrical equipment of the motor car and 4 1/4 for the remainder.

#### *Illinois Central.*

113 to 116, average cost per car \$27 143.00  
117 to 120, — — — — 26 871.00  
Time of depreciation, 25 years or 4 % each year.

#### *Philadelphia & Reading.*

	Each.
Three 250 H. P. gas-electric	\$40 618.29
One 250 — — —	38 625.75
— 350 — — —	56 000.00
— 360 — — —	60 000.00

Depreciated at 4 1/2 % per year.

*Central of Georgia.* — The purchase price of the rail gas car which is in service was \$19 000.00.

Time of depreciation 12 1/2 years.

*Louisville & Nashville.* — \$38 562.00.  
— 25 years.

*Ulster & Delaware.* — Blank.

*Pennsylvania.*

<i>Gasoline cars :</i>		
Weight	29 500 lb., cost . . .	\$17 000.00
—	55 000 lb., — . . .	27 000.00

<i>Gasoline-electric :</i>		
Weight	90 000 lb., cost . . .	\$35 000.00
—	116 000 lb., — . . .	42 000.00
—	122 000 lb., — . . .	45 000.00
—	132 000 lb., — . . .	51 000.00

See Question No. 11 for description of cars.

Time of depreciation, 36 years at 2 1/2 % per annum for bodies.

Time of depreciation, 5 years at 18 % per annum for power units.

#### *New York Central.*

Gas mechanical cars range from \$25 000.00 to \$35 000.00.

Gas electric, single power plant cars, \$45 000.00 to \$50 000.00.

The Diesel power plant gas-electric cars range from \$60 000.00 to \$65 000.00.

Rates of depreciation used which is applied to the entire unit, are 14 % for the gas-mechanical and 10 % for gas-electric cars.

QUESTION 127. — What is the annual mileage covered by your different motors? Comparison with ordinary locomotives?

#### Answers.

*Baltimore & Ohio.* — Blank.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Motor car has been in service only since May 1928, and the total mileage for a year should be about 35 000 miles. The car should make a much higher mileage than above if schedules would permit.

#### *Illinois Central.*

Car	113 . . . . .	44 772
"	114 . . . . .	27 746
"	115 . . . . .	54 317
"	116 . . . . .	20 082
"	117 . . . . .	22 134

Car	118 . . . . .	38 388
"	119 . . . . .	33 434
"	120 . . . . .	47 584

About the same for locomotives on these runs.

*Philadelphia & Reading.* — Approximately 60 000 miles, which is more than had been covered by ordinary locomotives.

*Central of Georgia.* — The rail gas car now in operation, will make 35 040 miles annually. As this is the only one in service, it will have to be compared with the steam locomotive which it replaced, which made the same mileage.

*Louisville & Nashville.* — 67 670 miles per year.

*Ulster & Delaware.* — Blank.

*New York Central.* — Average yearly mileage for the gas mechanical units has been approximately 50 000. It is estimated that similar yearly mileage will be made by the gas-electric motors.

#### *Pennsylvania.*

Gasoline cars . . . . .	37 800 miles per annum	
Gas-electric . . . . .	53 000	—
Steam locomotives . . . . .	60 000	—

ITEM 30. — Have you, having regard to the small importance of traffic and from economical consideration or competition, replaced the train service on any of your minor lines by road service using motors or tractors and trailers?

QUESTION 128. — a) For passenger and parcel traffic?

#### Answers.

*Baltimore & Ohio.* — Replacements of steam train service by rail motor cars have been from economic consideration, where a rail service is necessary but traffic light.

*Chesapeake & Ohio.* — No motors.

*Richmond, Fredericksburg & Potomac.* — Yes, we have replaced train service with highway motor buses for passenger service in one instance.

*Illinois Central.* — No.

*Philadelphia & Reading.* — Yes. Steam service replaced with gas-electric motors. Also motor coach service is in operation the service being performed by a subsidiary company.

*Central of Georgia.* — We have replaced passenger service on one minor line with highway bus service and have on order two buses which will replace passenger train service on two other minor lines.

These buses handle small baggage and parcels in addition to passengers.

*Louisville & Nashville.* — No.

*Ulster & Delaware.* — None.

*Pennsylvania.* — No.

QUESTION 120. — b) For freight traffic.

#### Answers.

*Baltimore & Ohio.* — None.

*Chesapeake & Ohio.* — Nothing.

*Richmond, Fredericksburg & Potomac.* — None.

*Illinois Central.* — None.

*Philadelphia & Reading.* — None.

*Central of Georgia.* — None.

*Louisville & Nashville.* — None.

*Ulster & Delaware.* — None.

*Pennsylvania.* — No.

QUESTION 130. — Please give information with regard to results, from the point of view of working expenses in competition?

#### Answers.

*Baltimore & Ohio.* — Marked reduction in operating expenses have been secured through the introduction of gas or gas electric rail motor cars. The use of such cars has not, however, been an effective means of competition, that is with the private automobile or highway motor coach.

*Chesapeake & Ohio.* — None.

*Richmond, Fredericksburg & Potomac.* — This service has just been inaugurated and no figures are available at this time.

*Illinois Central.* — None.

*Philadelphia & Reading.* — An approximate annual saving in steam train cost of \$51 724.40 due to operation of motor coach service and approximate annual saving in steam train cost of \$49 879.52 due to substitution of gas-electric motor service for steam service.

*Central of Georgia.* — In the one case where highway bus service replaced passenger train service, working expenses have been greatly reduced. Competition was not considered, as the passenger business on this line was reduced by the use of privately owned automobiles.

*Louisville & Nashville.* — Blank.

*Ulster & Delaware.* — Blank.

*Pennsylvania.* — See Questions Nos. 128 and 129.

**B. — Use of special tractors for shunting in smaller yards and for certain work in large yards.**

QUESTION 131. — Set out the special methods of traction that you use for small movements for example?

Answers.

*Baltimore & Ohio.* — At 26th Street, New York, Ingersoll Rand oil-electric locomotive. At Pier 40, Philadelphia, Plymouth gasoline locomotive. At Fell Street, Baltimore, Md., General Electric locomotive.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — We have no special methods in use for small movements; all movements of cars in yards or sidings are made by steam locomotives.

*Pennsylvania.* — See Questions Nos. 135 and 162.

QUESTION 132. — Horses.

Answers.

None in use.

QUESTION 133. — One-wheel push carts (wheel barrow type), with gasoline motor.

Answers.

None in use.

QUESTION 134. — Push carts or tractors, tricycle type, operated by hand?

Answers.

None in use.

QUESTION 135. — Locomotive tractors with combustion motors, or steam, or electric, on rails, with or without capstans fitted on the tractors?

Answers.

*Baltimore & Ohio.* — See answer to Question 131.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Only have steam switching locomotives.

*Pennsylvania.* — Yes, gasoline-electric tractors with rubber tires on four wheel drive and four wheel steering and equipped with automatic air brake.

See Question No. 162 and photograph attached, exhibit 35.

Tractor operates on paved surface.

QUESTION 136. — Ordinary wheel auto-tractors running in gangways?

Answers.

None in service.

QUESTION 137. — Caterpillar tractors?

Answers.

None in service.

QUESTION 138. — Capstans with cable.

Answers.

*Baltimore & Ohio.* — None.

*Philadelphia & Reading.* — At our grain elevator at ore docks at Port Richmond we use cable hauls for shifting and transferring cars to both the ore machines and to the car unloading machinery in the grain elevator. These systems work out very satisfactorily and are capable of handling from 6 to 10 loaded cars on level tracks.

*Central of Georgia.* — None.

*Pennsylvania.* — No.

QUESTION 139. — Hand windlasses with cables?

Answers.

None in use.

QUESTION 140. — Transfer cable with internal combustion or electric motor?

Answers.

*Baltimore & Ohio.* — Blank.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — We have one transfer cable, but this service is for passenger coach repair shop only.

*Pennsylvania.* — No.

QUESTION 141. — Cables worked by electric motor? Running on a bridge built above the track, etc.?

Answers.

None in use.

QUESTION 142. — Indicate the average number of trucks that can be dealt with at a time with the respective methods of traction : a) Loaded.

Answers.

*Pennsylvania.* — The available tractive power or draw-bar pull of 8 000 lb. will handle a variable number of cars, depending on the resistance due to their weight, the grade of track and curvature.

QUESTION 143. — b) Empty.

Answers.

*Pennsylvania.* — See Question No. 142.

QUESTION 144. — Also speed of movement and radius of operation (for example for cables)?

Answers.

*Pennsylvania.* — Fuel for 8 hours operation is carried.

Maximum speed is 12 miles per hour light and 3 miles per hour at 8 000 lb. draw-bar pull.

QUESTION 145. — How is grip obtained?

Answers.

Blank.

QUESTION 146. — Please describe the apparatus and attach plans with interesting details.

Answers.

*Pennsylvania.* — See Question No. 162.

QUESTION 147. — Information on the cases in which the different means are used?

Answers.

*Baltimore & Ohio.* — At New York a small yard in congested territory where no smoke is desired is used locomotive described. At Philadelphia, the small amount of switching at Pier 40 permits use of more economical piece apparatus than steam. At Baltimore, Fell Street, congested district and sharp curvatures require special equipment.

*Philadelphia & Reading.* — Blank.

*Central of Georgia.* — Blank.

*Pennsylvania.* — None.

QUESTION 148. — Various methods used.

Answers.

*Pennsylvania.* — See Question No. 135.

QUESTION 149. — Importance of daily performed operation?

Answers.

*Baltimore & Ohio.* — The operations in each case are at water front and are important in that they involve car transfers from isolated yards to floats for delivery to main yards.

*Philadelphia & Reading.* — See answer to No. 148.

*Central of Georgia.* — Blank.

*Pennsylvania.* — Very busy freight terminals.

QUESTION 150. — Kind of operation, for example, movement of cars in freight yards?

Answers.

*Baltimore & Ohio.* — See above. In addition switching to freight sheds and adjacent team and industrial sidings is done.

*Philadelphia & Reading.* — See answer to Question 148.

*Central of Georgia.* — Blank.

*Pennsylvania.* — Can be used wherever surface is provided.

QUESTION 151. — Shunting or placing of cars in freight yards, to avoid the use of a locomotive entering a siding?

Answers.

*Baltimore & Ohio.* — None.

*Philadelphia & Reading.* — Oil motors substituted for steam power, in some sections.

*Central of Georgia.* — Done only by steam locomotives.

*Pennsylvania.* — Used to avoid use of steam locomotive and because required by sharp curvature.

QUESTION 152. — Movement of cars in yards, docks, platforms, etc.

Answers.

*Baltimore & Ohio.* — See answer above.

*Philadelphia & Reading.* — Cars are placed at and moved from industries, and track service performed by motors, the track service covering a haul of about 6 miles.

*Central of Georgia.* — Movement of cars in yard etc., made by steam locomotives only.

*Pennsylvania.* — See Question No. 151.

QUESTION 153. — Particulars on the method in use as pushing or pulling?

Answers.

*Baltimore & Ohio.* — Push and pull.

*Philadelphia & Reading.* — In industrial switching, cars are pushed and pulled in track; service, pulled.

*Central of Georgia.* — No special particulars other than those performed in the average freight yard by steam switching locomotives.

*Pennsylvania.* — Is equipped with standard couplers and will either pull or push.

QUESTION 154. — Time used for getting up steam?

Answers.

*Baltimore & Ohio.* — Blank.

*Philadelphia & Reading.* — Cannot advise.

*Central of Georgia.* — 30 minutes to one hour according to the class of locomotive.

*Pennsylvania.* — Not required.

QUESTION 155. — Steps for security, brake arrangement?

Answers.

*Baltimore & Ohio.* — Nothing.

*Philadelphia & Reading.* — Same methods employed as if ordinary locomotives were used, that is hand brakes etc. are applied by men on the cars.

*Central of Georgia.* — All driving wheels and tender wheels are equipped with automatic air brakes.

*Pennsylvania.* — Hand brake and automatic brake.

QUESTION 156. — Difficulties experienced, for example, damage to track by auto-tractors not working on the rail?

Answers.

Blank.

QUESTION 157. — Men necessary, details on their routine. Are they specialized? From what service selected? Do they require special training?

Answers.

*Baltimore & Ohio.* — Regular engineers and yard crews used. Regular engineers taught to operate this special equipment.

*Philadelphia & Reading.* — See answer to 156.

*Central of Georgia.* — Our switching crews vary in number according to size of yard and number of cars handled. Minimum number is 5. Engineer and fireman, switch foreman, a conductor and two switchman. The number of switchmen is increased as required.

The men in switching service may be men from road service or may be men trained in yard.

*Pennsylvania.* — One operator required. He is selected from the train service, very little training required.

QUESTION 158. — Garaging arrangements. Are special installations necessary?

Answers.

*Pennsylvania.* — Shed to protect against weather, no special installation necessary.

QUESTION 159. — How long have you been using these various methods and do you intend to extend their use? If not, why not?

Answers.

*Baltimore & Ohio.* — Several years; will use special equipment wherever its use can be justified.

*Philadelphia & Reading.* — Nothing to report.

*Central of Georgia.* — See previous answers in this section.

*Pennsylvania.* — First machine built in 1913. Additional ones will be built if conditions warrant.

QUESTION 160. — Have you tried other methods than those which you now use? If so, with what results, why have you abandoned them, or do you expect to return to them?

Answers.

*Pennsylvania.* — Horses abandoned in favor of tractor. See Question No. 162 for comparative operation.

QUESTION 161. — Are you considering the use of other methods?

Answers.

*Pennsylvania.* — No.

QUESTION 162. — Please give descriptions and useful particulars, and special object aimed at?

Answers.

*Baltimore & Ohio.* — Special operating conditions which had to be met and desire for economical units.

*Philadelphia & Reading.* — Object aimed at is economy in operation, reduction of personal and reduction of hazard to employees.

*Central of Georgia.* — See previous answers.

*Pennsylvania.* — Does not run on rails, rubber tires, 4-wheel steer, 4-wheel brake, air and hand. Standard automatic air brake with 16 cubic-foot motor driven air compressor. Main generator is 26-42 kw.; 176-300 volts; 142 amperes 600-1 000 r. p. m.

Maximum speed 12 m. p. h. light, starting tractive effort 10 000 lb. and tractive effort at 3 m. p. h. is 8 000 lb.

Motors are vehicle type 176 volts, 70 amperes, 1 300 r. p. m.

Gasoline engine, Climax, 6-cylinder, 4-cycle, 5 1/2 inch  $\times$  7 inch and rated 65 H. P. at 600 r. p. m. and 105 H. P. at 1 000 r. p. m.

Engine is run at constant speed with variable voltage control for control of tractor speed.

Roof radiator of 44 gallons capacity and pump circulation.

Fuel system — Vacuum.

Starter — 12-volt Bendix.

Wheels — Cast steel with dual 6-inch  $\times$  60-inch rubber tires.

Cost of handling by tractor equals 28 % of contract price with horses; 5 tractors will handle more than 125 horses; 125 horses equal 14 teams.

14 teams require 14 crews of 1 driver and 1 brakeman.

5 tractor crews require 5 crews of 1 motorman and 1 brakeman.

We have no accurate data of cost per kilowatt generated on tractor.

See photograph, exhibit 35.

QUESTION 163. — Information as to results obtained, for example, from the point of view of regularity of working trains, the economical use of trucks, accidents, etc.?

Answers.

*Baltimore & Ohio.* — All desired results as to regularity of switching, lowered cost, etc. have been obtained.

*Philadelphia & Reading.* — Good results have been obtained, but we have no details to report.

*Central of Georgia.* — See previous answers.

*Pennsylvania.* — Cost reduced. Accidents reduced. Regularity improved. Service accelerated.

QUESTION 164. — Advantages and disadvantages to be noted, damages, immobility, comparison with the ordinary means to which one would have recourse in default of the methods mentioned?

Answers.

*Baltimore & Ohio.* — Advantage of greater mobility and lower costs as against other methods.

*Philadelphia & Reading.* — Nothing definite to report.

*Central of Georgia.* — See previous answers.

*Pennsylvania.* — See Question No. 162.

QUESTION 165. — Horses. Hourly rates or cost of hiring horses?

Answers.

Nothing to report.

QUESTION 166. — Pay of driver or other needed help.

Answers.

*Pennsylvania.* — Paid on same basis as steam locomotive of lightest switching type.

QUESTION 167. — Apparatus. Depreciation.

Answers.

*Baltimore & Ohio.* — Standard rate for steam locomotives is charged.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — As we have no special apparatus, we can only give depreciation on steam locomotive. This varies from 4 to 5 % per year according to the class of locomotive.

*Pennsylvania.* — 4 % per annum.



Exhibit 35.

## QUESTION 168. — Repairs.

## Answers.

*Baltimore & Ohio.* — Repairs average for oil electric-engine 32 cents per car handled, or 12.2 cents per engine-mile based on 6 miles per hour. Repairs average for Plymouth gasoline locomotive 18.8 cents per car handled or 3.15 cents per engine-mile on 6 miles per hour basis.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — Our locomotive repairs average approximately 19 cents per mile. This is for the entire system, as we do not keep the different classes separately.

*Pennsylvania.* — \$900.00 per year.

## QUESTION 169. — Maintenance?

## Answers.

*Baltimore & Ohio.* — See previous answers.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — See answer to No. 168.

*Pennsylvania.* — See Question No. 168.

## QUESTION 170. — Pay of necessary operators?

## Answers.

*Baltimore & Ohio.* — Standard engineers' rates of pay. Crew wages, oil electric, 51.3 cents per engine-mile on 6 miles per hour basis. Crew wages for Plymouth gasoline locomotive 41.3 cents per engine-mile on 6 miles per hour basis.

*Philadelphia & Reading.*

Motorman . . .	\$7.22 per day, 8 hours.
Motor attendant.	5.68 — —
Conductor . .	7.22 — —
Brakemen (2) .	6.62 — —

*Central of Georgia.* — No special operators. Engineer and ground crew paid standard wages.

*Pennsylvania.* — Repairmen are paid mechanics' or helpers' rate, depending on the qualification of the individual.

## QUESTION 171. — Purchase cost?

## Answers.

*Baltimore & Ohio.* — Cost of oil-electric (300 H. P.), \$61 522.66.

Cost of Plymouth gasoline locomotive, \$9 185.86.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — Purchase cost of steam switching locomotives used in yards varies from \$11 940.00 to \$18 015.95 being purchased in 1902, 1903, 1904 and 1905. We have no other method of moving cars.

*Pennsylvania.* — \$15 000.00.

## QUESTION 172. — Time of depreciation.

## Answers.

*Baltimore & Ohio.* — Standard.

*Philadelphia & Reading.* — No data available.

*Central of Georgia.* — Time of depreciation varies for 20 to 24 years.

*Pennsylvania.* — 36 years at 2 1/2 % per annum.

## QUESTION 173. — Cost of installation for storing of apparatus and equipments?

## Answers.

Nothing to report.

## REPORT No. 4

(America)

ON THE QUESTION OF LOCOMOTIVES OF NEW TYPES. IN PARTICULAR  
TURBINE LOCOMOTIVES AND INTERNAL COMBUSTION MOTOR LOCO-  
MOTIVES (SUBJECT V FOR DISCUSSION AT THE ELEVENTH SESSION  
OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) <sup>(1)</sup>.

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Figs. 1 to 21, pp. 860 and 865.

## I. — Internal combustion locomotives.

### A. — Introduction.

The internal combustion locomotive made its first appearance on the American Continent when a small one-cylinder gasoline locomotive of the 0-4-0 type was built in the United States some twenty five years ago. Since then, a number of gasoline locomotives have been built, mainly for factories, machine works, etc. Some of them have been used on railroads for light switching work, short hauls on suburban lines and similar service. Very little information can be secured on the performance of these locomotives. Some data are given in Appendix I.

The modern internal combustion locomotive in America dates from the time of the first Diesel locomotive.

Various designs had been made prior to the World War, but the first two Diesel locomotives in the world were built by the General Electric Company in 1917 and 1918. They had 200 - B. H. P. Diesel engines and were used in their shop yards; one of them is still in opera-

tion at the General Electric works in Erie. A railroad locomotive with a 300-B. H. P. Ingersoll-Rand oil engine was later developed, and was placed in service at the end of 1923. The locomotive became the prototype of the sixty-ton oil-electric locomotives, which have been built in large numbers since 1923 jointly by the General Electric, American Locomotive and Ingersoll-Rand Companies <sup>(1)</sup>. Larger locomotives with two 300-B. H. P. oil-engines of the same type, the so-called hundred-ton oil-electric locomotives, followed and since then locomotives with one and two oil-engines of 750 to 1 330-B. H. P. per engine unit, and 750 to 2 600 B. H. P. per locomotive, have been placed in service <sup>(1)(2)</sup>.

At present Diesel-locomotives seem to be in use on the American Continent only in the United States and Canada <sup>(3)</sup>.

(1) Particulars about the development of the Diesel locomotive can be found in «The Present Status of the Oil-Engine Locomotive» presented by the author of this report before the 1927 annual meeting of the American Railway Association, Mechanical Division. (See *Proceedings of the A.R.A., Mech. Div.*, 1927).

(2) The horse-power of the oil-engines and locomotives in this report is given in accordance with the engine builders' ratings. So far no uniformity in rating has been established, although attempts to introduce standard methods of rating have already been made.

(3) Only recently (December 1929) the reporter received information about several locomotives in Argentine (see Appendix II).

(1) This question runs as follows: «Locomotives of new types; in particular, turbine locomotives and internal combustion motor locomotives. Construction, efficiency, use and repair».

A questionnaire was sent out to the principal railroads of North and South American countries - to all participants of the International Railway Congress Association, as well as to non-participating roads which, according to the technical press, had had Diesel locomotives in operation. Very complete replies have been received from all railroads which operate locomotives of this type, and it gives the

author extreme pleasure to express here his profoundest thanks to the railroad officials whose comprehensive and laborious replies enabled him to compile the present report.

#### B. — General information.

Diesel-locomotives in use on the North American Continent on 1 July 1929, belong to the following types :

I. <sup>(1)</sup>	with one	300 B. H. P.	<sup>(2)</sup>	Ingersoll-Rand engine.
II.	— two	300 —		Ingersoll-Rand engines (600 B. H. P. total).
III.	— one	300 —		McIntosh & Seymour engine.
IV.	— one	300 —		Ingersoll-Rand engine with a large storage battery for traction.
V.	— two	300 —		Beardmore-Westinghouse engines (600 B. H. P. total).
VI.	— one	750 —		Ingersoll-Rand engine.
VII.	— one	900 —		McIntosh & Seymour engine.
VIII.	— two	1 330 —		Beardmore engines (2 660 B. H. P. total).

The general dimensions and principal characteristics of the locomotives are given in table I. Table II shows the distribution of locomotives among various railroads and industrial firms. Some general remarks will probably be of interest.

Only locomotives of types I and II have been built in any considerable numbers. All other types (III-VIII) seem to be experimental locomotives built in quantities seldom over one; some of them were placed in service only during the year of 1929 (VI-VIII). On the other hand, locomotives IV and V, which have been doing work since 1928, are making good progress, and orders for several

more of each type have been recently placed, or are in contemplation <sup>(1)</sup>. They will probably soon join the locomotives of types I and II.

All locomotives have electric transmission. Hydraulic, pneumatic (air), or steam transmission has never been tried in America, although all of the transmissions were thoroughly studied <sup>(2)</sup> and the Esslingen - M.A.N. locomotive for the German State Railways - and the Cristiani locomotive built by Kraus in Linz, Austria, are being carefully watched. The mechanical gear transmission with magnetic friction clutches and main hydraulic clutch has been employed in a

(1) This numeration is introduced for the use in this report only and does not represent classification of locomotives on respective railroads.

(2) These figures represent the output of the oil engines at their crank shafts.

(1) Since 1 July 1929, up to the present time (January 1930) orders amounting to 44 locomotives of type IV have been placed by several railroads for switching terminal and street track service in cities.

(2) *Mechanical Engineering*, Vol. 48, 1926, pp. 797 and 929.

1400-B. H. P. 4-8-4 locomotive built by Fr. Krupp of Essen, Germany, for the Boston & Maine Railroad, and is now being tested at the maker's plant in Essen.

The first two types (I-II) seem to have firmly established themselves in switching service in railroad yards and industrial plants. The road types have not yet gone beyond the experimental stage. This may have happened chronologically, the present period marked the end of the development of the switching locomotive and the beginning of the progress of the road locomotive. It is characteristic of the development of the Diesel locomotive in America that, contrary to the practice of some European countries, the problem of the switching locomotive was tackled first. This seems to be only logical, as the fuel economy, in view of the elimination of stand-by losses in steam locomotives, is more pronounced in switching than in road service, and because the oil-electric locomotive meets better the requirements of city authorities as to smokeless exhaust from switching engines within city limits than the steam engine. The application of the oil-electric locomotive to switching service may have also contributed to the preponderance of electric transmission, because the sharp curves in switching yards called for the use of trucks to which power is more easily transmitted by electrical than by mechanical, hydraulic or other means.

A brief description of each of the enumerated types is given below. For more complete information the reader is referred to the footnotes given at the end of each description.

#### C. — Description of locomotives.

*Type I.* — This is the well-known 60-ton oil-electric locomotive, because the first units which were built with compa-

ratively light motors, without blowers for cooling them, and without fans for the radiators (water coolers), weighed about 60 short tons. The weight of the latest locomotives of this type is between 64 and 70 tons <sup>(1)</sup>, depending upon the type of motors used. The prime mover is a six-cylinder, four-cycle, single-acting oil-engine working on the dual (constant-volume and constant-pressure) cycle, with airless (mechanical) injection, built by the Ingersoll-Rand Company. The engine develops 300 B. H. P. at 550 revolutions per minute and weighs a little over 19 000 lb., including base between crank shaft and locomotive frame. The engine is made of ordinary material - cast iron and forged steel. If made with aluminum base and covers, the weight could be reduced to 18 000 lb., or 60 lb. per 1 B. H. P. The cylinder sizes are 10 inches bore by 12 inches stroke, the piston speed being 1 400 f. p. m. One oil fuel pump with a single plunger serves all six cylinders through a properly timed six-feed rotary distributor of a special design. Each cylinder has a separate combustion chamber with two opposed spray nozzles, the combustion chamber being connected with the cylinder by a narrow neck for creating turbulence and proper combustion, this construction following the Price-Rathbun system, as shown diagrammatically on figure 1. The valves and spray nozzles are placed in the head, whereas the neck is formed in an intermediate part which is placed between the cylinder and cylinder head. The fuel consumption per one B. H. P. hour is about 0.45 lb. of oil with heat value of 18 500 B. T. U. per lb.

(1) The ton in this report is the American short ton of 2 000 lb. and equals 0.9072 metric ton and 0.893 English long ton.

## Types of oil-engine locomotives in operation

Type. — Serial number . . . . .	I.	II.	III.
Gauge . . . . .	Standard (1).	Standard (1).	Standard (1).
Builders . . . . .	ALCo. G. E. (6) I. R. (8)	ALCo (2) G. E. (6) I. R. (8)	Brill (3) McI-S. (9) G. E. (8)
Wheel arrangement . . . . .	B-B.	B-B.	B-B.
Weight-total, lb. . . . .	140 000	220 000	152 000
Weight on drivers, lb. . . . .	140 000	220 000	152 000
Length, inside of knuckles . . . . .	34 ft. 6 in.	41 feet.	39 ft. 6 in.
Total wheelbase . . . . .	23 ft. 6 in.	28 ft. 6 in.	28 feet.
Rigid wheelbase . . . . .	7 ft. 6 in.	8 feet.	7 ft. 6 in.
Cabs per locomotive . . . . .	1	1	1
Length over cab . . . . .	27 feet	34 feet.	33 feet.
Diameter of drivers, inches . . . . .	38	40	36
Diameter of idling wheels, inches . . . . .	...	...	...
Oil engines per locomotive . . . . .	1	2	1
Type of engine, cycle . . . . .	4-stroke.	4-stroke.	4-stroke.
Type of engine, injection . . . . .	Mechan. (11)	Mechan. (11)	Air.
Number of cylinders per engine . . . . .	6	6	12
Size of cylinders, inches . . . . .	10×12	10×12	8×9 1/2
Speed, revolutions per minute . . . . .	550	550	550
Rating per engine, B. H. P. . . . .	300	300	300
Rating of locomotive . . . . .	300	600	300
Generator, type . . . . .	G. E. (13) DT-502	G. E. (13) DT-502	G. E. DT-502
Number of generators per locomotive . . . . .	1	2	1
Rating of generators, kw. . . . .	200	200	200
Amperes (continuous) . . . . .	400	400	400
Motors per locomotive . . . . .	4	4	4
Motors, type . . . . .	G. E.-297 (14)	G. E.-287 (14)	HM-840
Continuous rating, amperes . . . . .	285	540	...
Hourly rating, amperes . . . . .	340	665	165
System of ventilation of motors . . . . .	Forced.	Forced.	S. V. (15)
Electric control . . . . .	L. A. (17)	L. A. (17)	L. A. (17)
Method of starting . . . . .	E. B. (20)	E. B. (20)	E. B. (20)
Capacity of starting battery, ampere-hours . . . . .	100	100	204
Location of cooling radiator . . . . .	O. R. (21)	O. R. (21)	I. C. (22)
Ventilation of cooling radiator . . . . .	F. B. (23)	F. B. (23)	F. B. (23)
Traction effort, adh. lb. (24) . . . . .	35 000	55 000	38 000
— — hourly, lb. (25) . . . . .	21 600	33 000	16 000
— — continuous (25) . . . . .	16 800	24 500	...

(1) Standard = 4 ft. 8-1/2 in. — (2) American Locomotive Company. — (3) J. G. Brill Company. — (4) Baldwin Locomotive Works. — (5) Canadian Locomotive Company. — (6) General Electric Company. — (7) Westinghouse Electric and Manufacturing Company. — (8) Ingersoll-Rand Company. — (9) McIntosh and Seymour Corporation. — (10) Wm. Beardmore and Co., Ltd. — (11) Mechanical (solid injection). — (12) Continuous. — (13) Several locomotives are equipped with DT-515 generator with a continuous rating

# American Railroads on the 1st of July 1929.

IV.	V.	VI.	VII.	VIII.
Standard (1).	Standard (1).	Standard (1).	Standard (1).	Standard (1).
ALCo (2)	Bald. (4)	ALCo (2)	ALCo (2)	Can. Loco. (5)
G. E. (6)	West. (7)	G. E. (6)	G. E. (6)	Beardmore (10)
I. R. (8)		I. R. (8)	McI-S. (9)	West (7)
B-B.	B-B	2-D-2	2-D-2	2-D-1+1-D-2
257 000	174 000	295 000	361 500	650 000
257 000	174 000	175 000	185 000	480 000
46 ft. 8 in.	46 ft. 10 in.	52 ft. 1 in.	59 ft. 4 in.	94 ft. 1 in.
34 ft. 1 in.	32 ft. 1 1/8 in.	42 ft. 10 in.	49 ft. 4 in.	84 feet.
8 ft. 3 in.	9 ft. 6 in.	17 ft. 6 in.	18 ft. 6 in.	17 ft. 1 in.
1	2	1	1	■
43 feet.	20 feet.	46 ft. 5 1/2 in.	55 feet.	47 ft. 1/2 in.
44	38	44	44	51
...	...	30	30	34-1/4
1	2	1	1	2
4-stroke.	4-stroke.	4-stroke.	4-stroke.	4-stroke.
Mechan. (11)	Mechan. (11)	Mechan. (11)	Air.	Mechan. (11)
6	■	■	12	12
10×12	8 1/4×12	14 3/4×16	14×18	12×12
550	800	500	310	800
300	300	750	900	1 330
300 (12)	600	750	900	2 660
G. E.	West.	G. E.	G. E.	West.
DT-502	477	DT-752	DT-751	478
1	2	1	1	■
200	210	500	500	1 170
400	420	1 600	1 400	1 300
4	4	4	4	■
G. E. 286	308-H	G. E. 286	G. E. 286	W-359
460	140	400	360	625
575	300	540	540	900
Forced.	N. V. (16)	Forced.	Forced.	Forced.
L. A. (17)	T. C. (18)	R. C. (19)	R. C. (19)	T. C. (18)
E. B. (20)	E. B. (20)	By air.	By air.	E. B. (20)
680	544	135	150	680
O. R. (21)	O. R. (21)	I. C. (22)	I. C. (22)	O. R. (21)
F. B. (23)	F. B. (23)	F. B. (23)	F. B. (23)	F. B. (23)
64 250	43 500	43 750	46 300	120 000
36 000	19 500	32 800	25 600	58 000
26 400	6 500	22 000	14 000	42 000

f 540 amperes at 120° C. rise. — (14) Several locomotives were equipped with other motors, depending upon  
 the service. — (15) Self-ventilated. — (16) Non-ventilated. — (17) Lamp-automatic. — (18) Torque control.  
 — (19) Resistance control. — (20) Electrically from a storage battery. — (21) On the roof. — (22) Inside  
 the cab. — (23) Forced, by air from blowers. — (24) Corresponding to a coefficient of adhesion of 0.25 (factor  
 of adhesion 4). — (25) For motors as given above (see 14).

TABLE II.  
Distribution of oil-engine locomotives between railroads and industrial firms in America  
on 1st July 1929.

Item.	NAME OF OPERATOR.	TYPES OF LOCOMOTIVES.							
		I	II	III	IV	V	VI	VII	VIII
		Total.							
		Number of locomotives.							
1	Central Railroad of New Jersey . . . . .	1	—	—	—	—	—	—	1
2	Baltimore & Ohio Railroad . . . . .	1	—	—	—	—	—	—	1
3	Lehigh Valley Railroad . . . . .	1	—	1	—	—	—	—	2
4	Long Island Railroad . . . . .	—	2	—	—	1	—	—	3
5	Great Northern Railway . . . . .	—	1	—	—	—	—	—	1
6	Erie Railroad . . . . .	2	2	—	—	—	—	—	4
7	Chicago & Northwestern Railroad . . . . .	3	—	—	—	—	—	—	3
8	Reading Railroad . . . . .	2	—	—	—	—	—	—	2
9	Delaware, Lackawanna & Western Railroad . . . . .	2	—	—	—	—	—	—	2
10	New York Central Railroad . . . . .	—	—	—	1	—	1	1	3
11	Illinois Central Railroad . . . . .	1	—	—	—	—	—	—	1
12	Hoboken Manufacturer's Railroad . . . . .	2	—	—	—	—	—	—	2
13	Canadian National Railways . . . . .	—	—	—	—	—	—	—	1
14	Total on railroads . . . . .	15	5	1	1	1	1	1	26
15	Various industrial firms . . . . .	11	2	—	—	—	—	—	13
	Grand total . . . . .	26	7	1	1	1	1	1	39

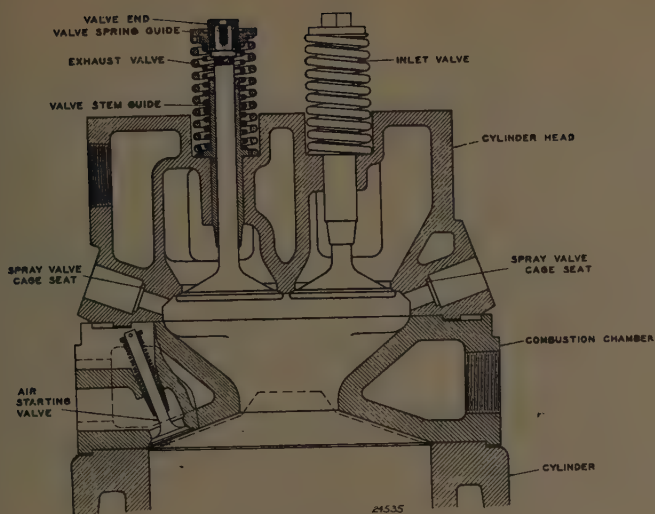


Fig. 1.

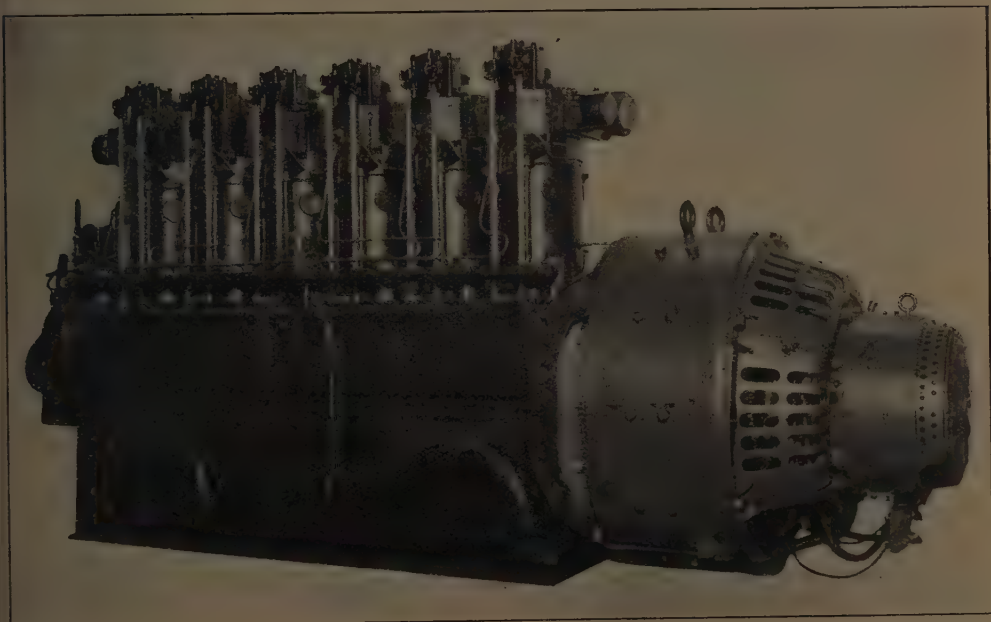


Fig. 2.

The oil engine is started either by air from air bottles which are charged by a small compressor built in the engine, or electrically from a 100 ampere-hour storage battery which permits turning the generator for several revolutions as a motor, from standstill to the firing speed of the oil-engine. The electric method of starting has been used on all latest locomotives, and the small compressor built in the first engine has been dispensed with, as well as the auxiliary emergency compressor driven by a gasoline engine usually provided for locomotives with engines started by air.

The generator is a 200-kw., 600-volt, compound wound, six-pole, direct current dynamo, directly fastened to the oil-engine frame (Fig. 2). The armature shaft is connected to the oil-engine crank shaft by a flexible coupling without any intermediate bearing. There is only one bearing in the overhang outside end. Two lugs, one on each side of the generator frame, permit the generator to bear against the locomotive frame, the connection consisting of only a bolt and a spring with a concentric vertical axis.

There are in the locomotive four geared motors, one for each axle, mounted on two trucks. They are the known General Electric traction motors of the series-wound, totally enclosed, commutating-pole, split frame type. The rating of the motors is different, depending upon the service which they are to perform - whether low-speed heavy-dragging, or higher-speed pulling and pushing. The motors are arranged in two pairs, which are permanently connected in multiple, and these pairs can be coupled in series usually for speeds below 4 miles per hour, or in parallel for speeds above 4 miles per hour. The rail tractive effort of this locomotive (at the rims of

the wheels) plotted against speed is given in figure 3. In the majority of cases the motors are cooled by motor-driven blowers. The motor ratings are given in table I.

The electric control is of the automatic Lemp type universally used on motor locomotives, rail cars and buses with General Electric equipment. The generator is energized through a separately excited field from an exciter (fig. 4), which in turn is energized from a storage battery. The current from the main generator passes through a differential series field, in addition to the commutating field, and then goes to the load - the series motors of the locomotive, air compressor, etc. When the throttle, manually controlling the oil admission to the engine is opened, it first establishes a contact for the storage battery circuit, thus energizing the exciter. At subsequent positions of the throttle handle the speed of the oil engine goes up and the torque of the engine at any definite position of the throttle handle is determined. If the load is less than the output of the generator, the flow of current through the differential series field drops and the energizing of the generator field goes up, resulting in higher voltage of the generator corresponding with the higher speed of the motors. Thus the speed of the motors automatically stabilizes in accordance with the load, drawing substantially constant energy corresponding to the output of the oil-engine. No rheostats are used in the power circuit for speed control. The position of the throttle handle, which is the only operating handle, determines the power of the oil-engine and of the electric generator, which is then resolved automatically into torque and speed to suit the conditions of the load. The reversal is obtained by reversing the pola-

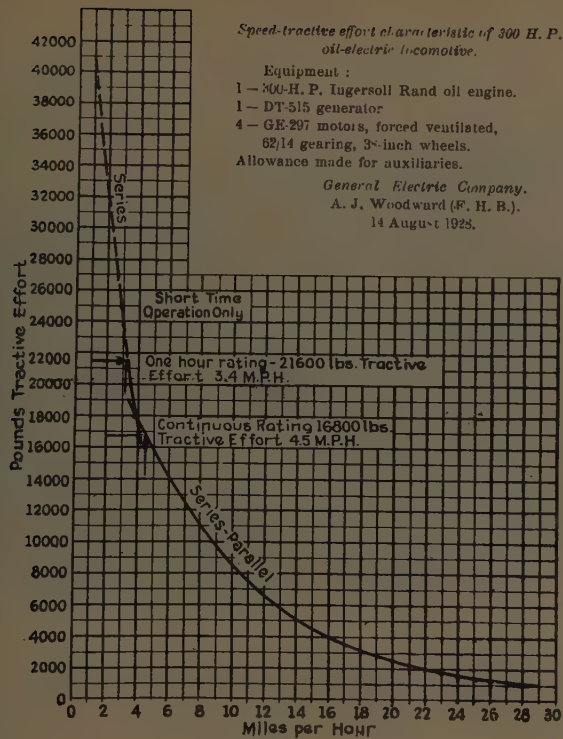


Fig. 3.

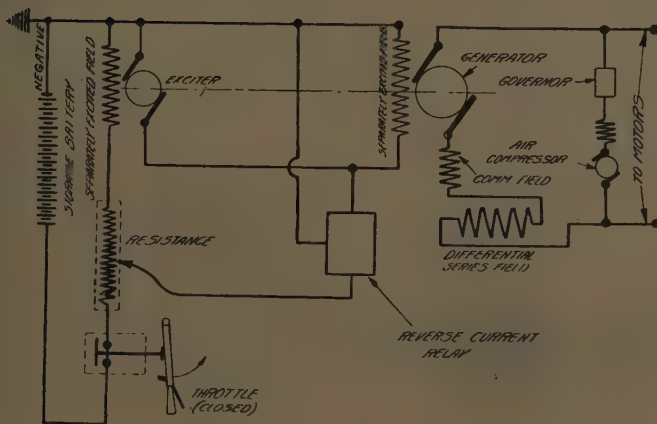


Fig. 4.

rity of the motor fields by the controller handle <sup>(1)</sup>.

The locomotive frame is of the built-up type, made of structural steel, and carries an enclosed, riveted all over, rectangular cab of the usual electric locomotive type. The locomotive is supported by two swivel trucks of the pedestal type, each carrying four solid rolled steel driving wheels (without separate tires) of 36 inches or 38 inches in diameter, depending upon the size of the motors and clearance diagram of the particular railroad.

The cab has two control compartments, one at each end, making the use of turntables unnecessary. The control compartment is equipped with handles, gauges, thermometers, etc. The large middle compartment contains the power plant and all auxiliaries of the locomotive. The middle part of the roof is removable to permit the lifting of the engine with generator from the cab for repairs.

The water and lubricating oil cooler (radiator) is of the fin-tube type (circular copper tube with outside spiral fins) and is located on one end of the roof and equipped with two motor-driven fans which suck the air from the sides and discharge it through the top. The early locomotives of this type had no fans, the cooling depending only on natural circulation of air while the locomotive was in motion. The water circulating pump is attached to the oil-engine; and so is the lubricating pump which provides the force feed lubrication for the oil engine.

Air for air brakes is delivered by a

motor-driven air compressor. Some of the earliest locomotives had compressors with a capacity of 100 cubic feet of free air per minute, but the capacity of the latest units is only 50 cubic feet of free air compressed to 90-140 lb. per square inch. Four 10-inch by 8-inch brake cylinders are provided on the more recent locomotives — two per each truck; the earliest locomotives had only one 16-inch by 12-inch cylinder bolted to the locomotive frame.

For heating each control compartment is equipped with radiators connected to a small coal burning water heater. The circulating system in the latest locomotives is so arranged that it can be heated from the oil-engine when it is running. In addition the heater can keep the engine jacket water from freezing when the engine is not running. In this case the radiators are empty, the water having been drained into the water tank placed in the cab above the engine.

All other auxiliaries, like sanders, headlights, lamps, signals, tools, etc., are of usual type.

Figure 5 shows one of the latest locomotives of this type and figure 6 gives diagrammatically the location of apparatus inside the cab <sup>(1)</sup>. The locomotive can pass curves with a minimum radius of 50 feet when alone and 90 feet with a train.

One locomotive, of type I built for the Hoboken Railroad and Terminal Company has a one-piece cast steel frame manufactured by the Commonwealth Steel Company of Granite City, Ill. The oil engine and generator are bolted to the steel frame separately; the generator is thus of the conventional design, but with

(1) « Electric Transmission for Internal Combustion Engines », by Herman Lemp, *Mechanical Engineering*, No. 3, March, 1926, p. 207; also « Die Steuerung Deselektischer Lokomotiven », by Süßerkühn, *Zeitschrift des Vereines Deutscher Ingenieure*, 28 April, 1928, p. 560.

(1) « New 60-Ton Oil-Electric Locomotive », *Oil Engine Power*, September, 1925, pp. 510-515.



Fig. 5.

American Locomotive Company,  
New-York.  
Class, 404 - OE - 431.

Ingersoll Rand Company,  
New-York.  
*Built for the Reading Company.*

General Electric Company,  
Schenectady, N.-Y.  
Road number 51.

Weight in pounds, working order		1- 300 H. P. oil engine			Motors				Gauge of track
Total	Driving wheels	Cylinders	Diam.	Stroke	Type	Number	Gear ratio	Suspension	
131 000	131 000	6	10 "	12 "	HM 840-G	4	5.86	Spring, Nose	4'-8 1/2"
Capacity					Wheel base				
Switching service					Driving	Rigid	Total		
Tractive effort, pound.		Speed, miles			24'-2"	7'-2"	24'-2"		
36 000		Starting			Wheel diameter		Axles		
15 000		4.5			1 hour rating		Driving		
7 900		10			Continu us		Journal		Center
		30			Max. speed		5" X 9"		3 1/2'

only one bearing at the extreme end, designated by the General Electric Company as DT-515. The rating is the same as that of DT-502. A coupling with axial flexibility is used between the oil-engine and generator, as on all other locomotives of this type.

*Type II.* — This is the 100-ton oil-electric locomotive, the weight of which is between 104 and 110 short tons, depending upon the type of motors used. These locomotives are equipped each with two 300-B. H. P. engines and two 200-kw. generators of the same hung-on type as the locomotive just described; they have been built jointly by the same three companies except two locomotives up to July 1929 built by the General Electric and Ingersoll-Rand Companies. Figure 7 shows the arrangement of the engines and apparatus in the cab of the double-engined locomotive, both in sectional elevation and in plan view. Each generator is directly bolted to the corresponding oil-engine, and the two units are staggered in order to provide a better passage in the cab and uniform distribution of weight.

The motors are four in number, as in the 300-H. P. locomotive, but differ in size. They are also direct current traction motors manufactured by the General Electric Company, and are likewise of the series-wound, commutating pole split-frame and nose-suspended type. The ratings of the motors and the principal dimensions of the locomotive are given in table I. The speed control is of the same automatic Lemp type described above. Similarly to the type I locomotive, there are two handles — one is the throttle lever, which controls the output of the engines, and the other is the master controller handle which connects

the motors either in series or in parallel, or in parallel with shunted fields, both for forward and backward movements. The tractive effort curve is given in figure 8. The motor gear ratio is 4.25 and allowance is made for power absorbed by auxiliaries. The locomotive can pass curves with a minimum radius of 75 feet when alone and of 100 feet with a train.

The design of the frame, cab, trucks and auxiliaries is the same as that of corresponding parts in the locomotive of the preceding type; the dimensions are, of course, larger in view of the greater power of the locomotive. There are two cooling radiators on the roof instead of one; the air compressor is approximately of double capacity — on some locomotives two motor-driven air compressors are provided, each of a capacity of 50 cubic feet of free air per m. Four 12-inch by 10-inch brake cylinders are used per locomotive. In earlier engines there was one 18-inch by 12-inch cylinder bolted to the locomotive frame<sup>(1)</sup>.

In three locomotives — on the Long Island Railroad, Hoboken Railroad and Terminal Company, and the Illinois Central Railroad — the frame is a one-piece solid steel casting of the same type and manufactured by the same Company as in the type I locomotive for the second of the three Railroads referred to above. The generator is likewise bolted to the frame separately, and is designated as DT-515, except in the Long Island locomotive, which has a slightly different generator — DT-512. The ratings in all cases are the same.

*Type III.* — This is also a 300-B. H. P. locomotive, differing from type I mainly in the oil-engine. It has twelve cylin-

(1) *Railway Mechanical Engineer*, February, 1920, pp. 92-95.

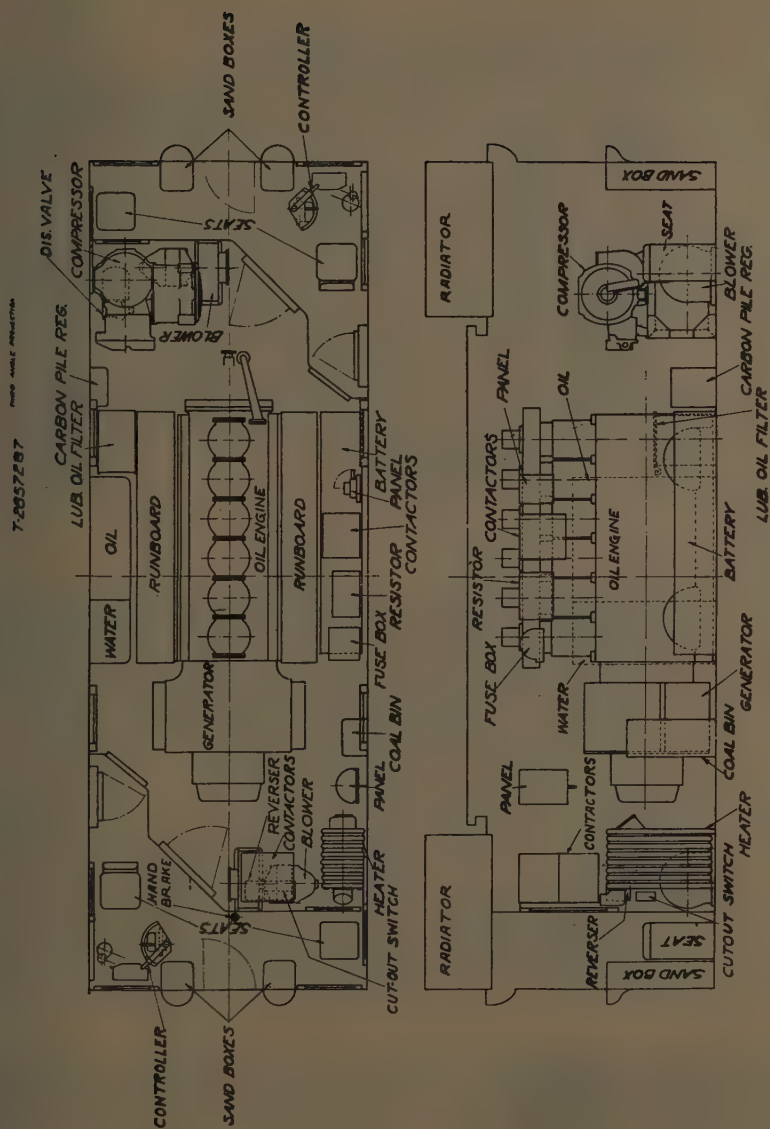
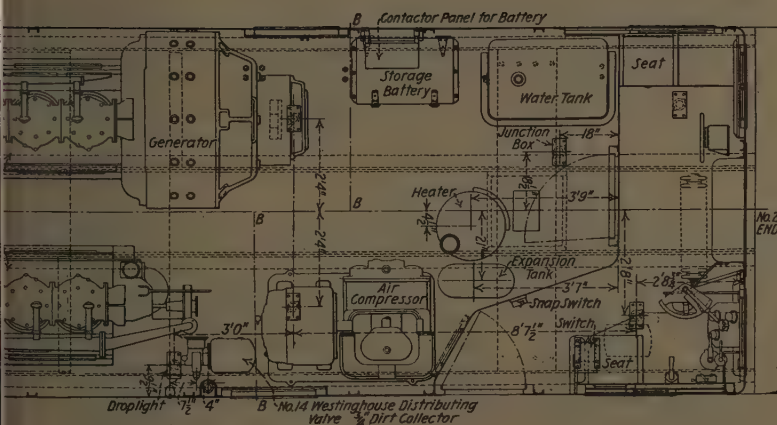
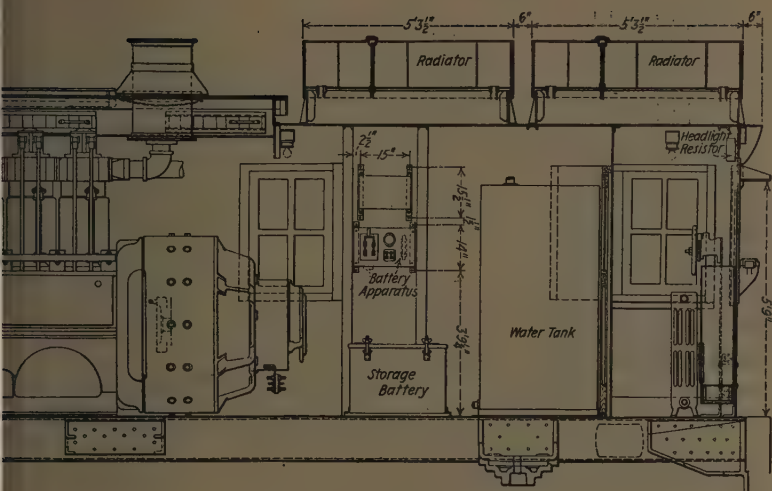


Fig. 6.





at 550 revolutions per minute and weighs, with fly wheel and sub-base, about 21 000 lb. The engine is made of ordi-

nary material (cast iron and carbon steel), except base and frame, which are cast of semi-steel with light sections.

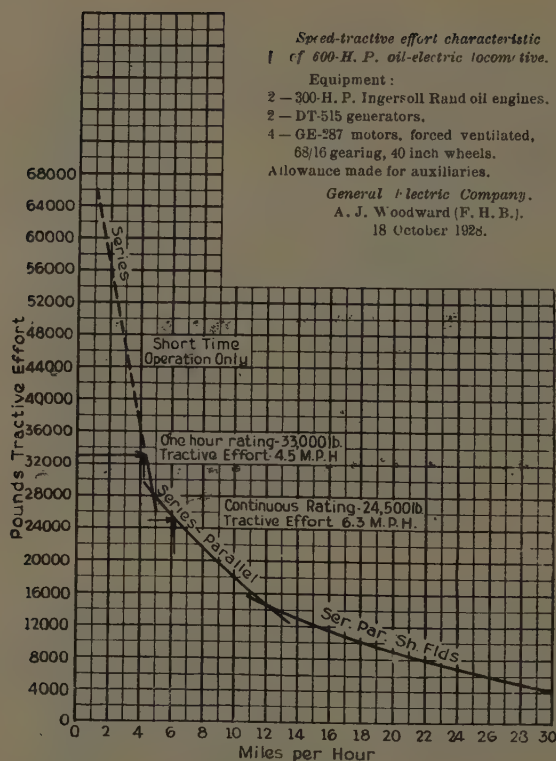


Fig. 8.

The twelve cylinders have 8 inches bore and 9 1/2 inches stroke; the piston speed is thus only 870 feet per minute. The shaft has six cranks, two connecting rods of each pair of cylinders acting on one pin of double length. The three-stage air compressor, with inter-stage coolers, which provides injection air, is mounted on one end of the engine; its piston is of the stepped trunk type. The fuel consumption per one B. H. P. hour is about 0.48 lb. of oil with heat value of 19 500 B. T. U. per lb. The idling speed

of the engine, which is about 300 r. p. m., is controlled by a solenoid idling governor cut in when the throttle handle is in the idling position; the solenoid is actuated by the exciter current, and as the speed of the engine, and consequently, of the exciter, goes up or down, the solenoid acts accordingly on the eccentric of the fuel pump. At other positions of the handle the solenoid is cut out and the speed is obtained by the mechanical action of the handle on the eccentric of the fuel pump, which varies the effective



pump, the lubricating oil pump and the air brake compressor are built in the engine.

III—9

550-r. p. m. compound wound, six-pole, direct current dynamo, coupled to the oil-engine and bolted separately to a common oil-engine sub-base. The armature shaft is connected to the oil-engine crank shaft by a coupling with torsional flexibility; there is only one outside bearing for the armature shaft, with no bearing between generator and oil-engine. The generator is used as a motor for starting the engine by connecting it directly to a 128-volt storage battery, automatically recharged from the exciter at speeds over a certain limit.

The motors are of the General Electric series-wound, commutating-pole, nose-suspended, traction type, four in number, each geared with a ratio of 41 : 7 to a driving axle of two two-axle trucks. The rating of the motors is given in table I. The motors can be connected in series, in parallel, or in parallel with shunted fields. The electric control is of the Lemp automatic type, the same as on the two preceding types. The reversal and the proper connections are obtained from a master controller with three forward, three backward and one neutral position.

In addition, there is a starting controller with a handle and five notches — one « off » position and four active points. In the « off » position the fuel and air valves are closed and the engine is stopped; the first active notch connects the battery to the generator and turns the engine; the following two notches actuate two electro-pneumatic pistons, of which one opens the injection air connection to the engine and the other starts the fuel pump. The fourth notch is the running position at which the battery is disconnected, but the air and fuel connections remain open. At this position the engine can run either idle, or at

variable speed and power, and the locomotive can be either at standstill or doing work, forward or backward, depending upon the positions of the master controller and throttle. If the starting controller handle is brought into the « off » position, everything stops.

The locomotive frame is of the built-up type made of structural steel and carries a riveted rectangular cab. The locomotive is supported by two swivel trucks of the pedestal type, each carrying four solid rolled steel driving wheels of 36 inches diameter. The locomotive can pass curves with a minimum radius of 90 feet. Similar to other locomotives, the cab has three compartments; the two end compartments are reserved for control and operation, whereas the middle compartment contains the power plant and auxiliaries, including radiators of 1/2 inch copper tubes with fins for cooling the circulating water of the oil engine. The radiators are equipped with two 5-H. P. motor driven fans. The locomotive is also provided with a coal burning hot water heater <sup>(1)</sup>.

Figure 10 shows the outside view of the locomotive, while figure 11 gives the tractive effort curve.

*Type IV.* — This is a combination of an oil-electric locomotive with a storage battery locomotive and the addition of overhead and third rail connections. While the power plant has a capacity of only 300 H. P., the locomotive can develop on internal power 720 H. P. for an hour, and up to 1000 H. P. for a short time, at starting and accelerating. On external power (through overhead or third rail connection on electrified tracks)

(1) « Diesel-electric switching », *Bulletin 112*, December 1927, McIntosh & Seymour Corporation, Auburn, N. Y.

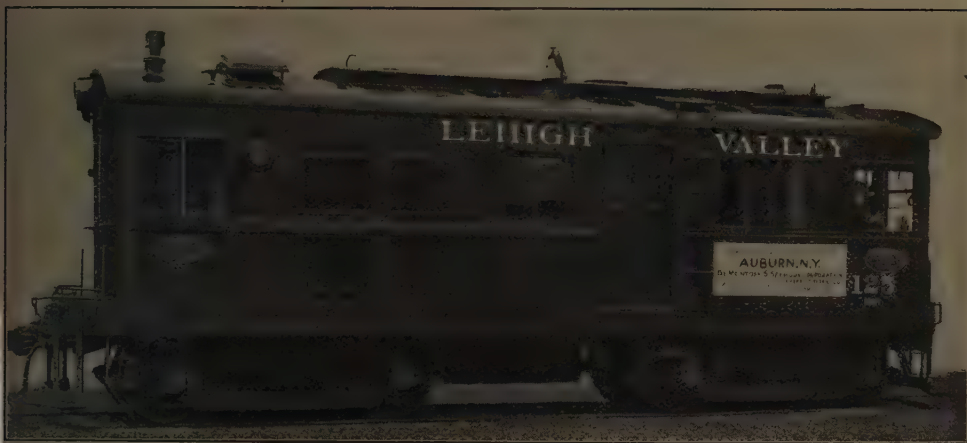


Fig. 10.

the motors are able to deliver 1 600 H. P. for one hour. With the oil engine charging the battery the locomotive can be operated up to 300 H. P. indefinitely, of course, within the lifetime of the battery. The locomotive has further the advantage that with the oil-engine shut down it can work in buildings, terminals, or any place where smoke is objectionable. The locomotive has actually been doing switching work in the West Side yards of New York, within the city boundaries of lower Manhattan.

The oil engine is the same 300 B. H. P. Ingersoll-Rand engine as used in the above described types I and II. The engine differs only in that it has a constant speed governor, the engine thus always running at its normal speed, approximately at 350 r. p. m., which gives the lowest fuel consumption.

The generator (DT-502) is, with respect to size, design and type, the same as in the majority of type I and II locomotives

(fig. 2). The traction motors, though, are different — more powerful than the motors of type I locomotives and are known as GE-286; they are 600-volt, series-wound, commutating-pole, air ventilated machines, geared with a ratio of 72 : 17 to four driving axles. The same motors are used on many switching locomotives of the New York Central Railroad. Their output rating at 600 volts is about 400 H.P. for one hour, and 280 H.P. for continuous service. Their rating in amperes is given in table I for a temperature rise not over 120° C. (248° F.).

The generator delivers power to the traction motors and to the storage battery at the same time without overloading the engine, and returns automatically to charging the battery as soon as the load decreases. The electric control is not automatic; it has resistance steps for accelerating the locomotive both with internal and external power operation. The motors can be connected all four in

series, or in series parallel, or in parallel. Figure 12 gives the corresponding tractive efforts.

The storage battery consists of 218 cells and has at six-hour rating a 680 ampere-hour, and a 294 kw.-hour capacity. An ampere-hour meter indicates the state of charge, and an integrating ampere-hour meter shows on one dial the total ampere-hours of discharge, and on another dial the total ampere-hours of charge.

The frame is a one-piece Commonwealth steel casting; the truck frames are also of the one-piece Commonwealth type cast integral with the transom and pedestals. The transom of each truck frame is a hollow box casting which serves as a duct for air used for the ventilation of two motors. The wheels are solid rolled steel wheels of 44 inches diameter; the cab is riveted to the frame. The storage batteries are arranged in three tiers. The central section of the cab contains the power plant, the control and the usual auxiliaries. There are two operating compartments at each end of the locomotive.

Fan blown fin-tube radiators are located on the roof in the usual manner. A 100-cubic foot air compressor provides air for the brakes. Four brake cylinders of 12 inches by 10 inches are mounted on the two trucks <sup>(1)</sup>.

Figure 13 gives a view of the locomotive. It was built in Schenectady Shops by the American Locomotive Company in conjunction with the General Electric Company, the Ingersoll-Rand Company, and the Electric Storage Battery Company.

*Type V.* — This is a 600-H. P. switching locomotive comparable in power to type II but differing in other respects: it has two cabs, each with its own power plant, motors, control and auxiliaries, and actually represents two separate units of the 0-4-0 type coupled by means of a drawbar; if the latter be replaced by two American couplers of the usual type, the two 300-H. P. units could be operated independently. Further, the oil engines are of a special light-weight, high speed design (Beardmore type); the weight of the high speed generators is correspondingly lower and the traction motors, not being of the heavy-drag-type, are lighter. As a result, the total weight of the locomotive is only 87 tons, as compared with 104-110 tons of type II. Rated tractive efforts (hourly and continuous) and other particulars are given in table I.

The locomotive was built for the Long Island Railroad by the Baldwin Locomotive Works and Westinghouse Electric and Manufacturing Company. The prime mover is a Westinghouse-Beardmore six-cylinder, four-stroke, single-acting, airless-injection, variable-speed engine, developing 300 B. H. P. at 800 r. p. m. Its idling speed is 300 r. p. m. and the working range is from 300 to 800 r. p. m. By the use of special material, such as cast steel and aluminium, a very light engine was obtained, weighing only 7 000 lb., including fly wheel, or 23.3 lb., per H. P. There is one oil-engine in each of the two cabs.

The generator is a direct-current, 210-kw., 750-volt, dynamo (Westinghouse type 477), with one outside bearing. The generator is directly bolted to the engine fly wheel. The exciter is a 5.3-kw., 64-volt, auxiliary generator; it furnishes power for the air compressor and charges the battery when the main generator is

(1) *Railway Age*, 3 March, 1928, pp. 525-527, and *Oil Engine Power*, March, 1928, pp. 165-167.

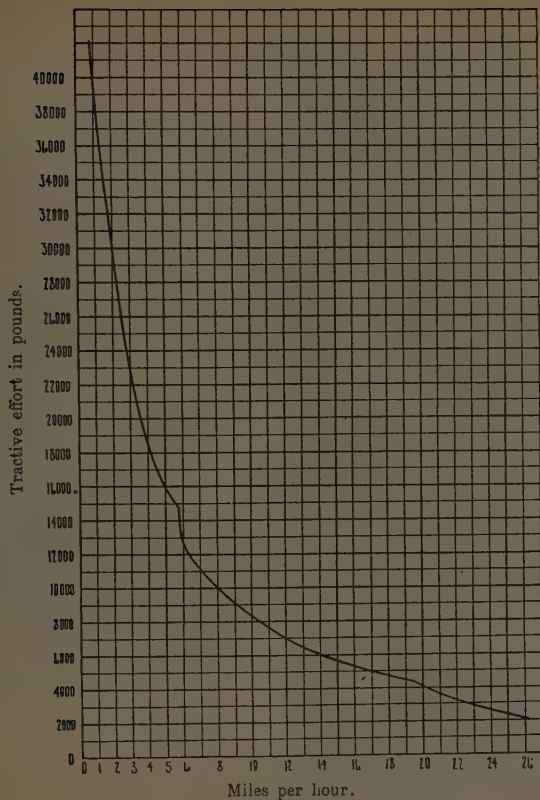


Fig. 11.

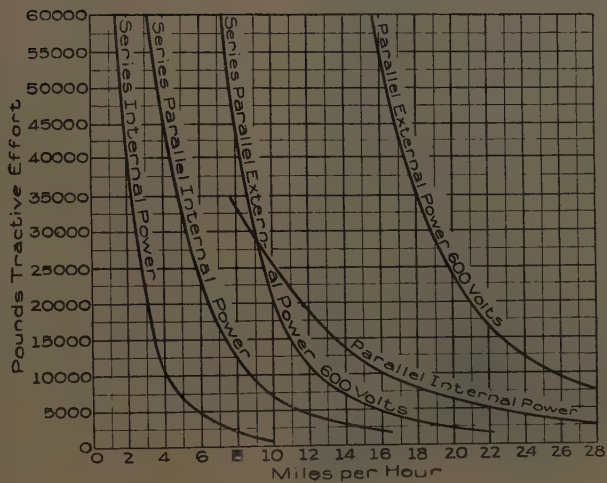


Fig. 12.

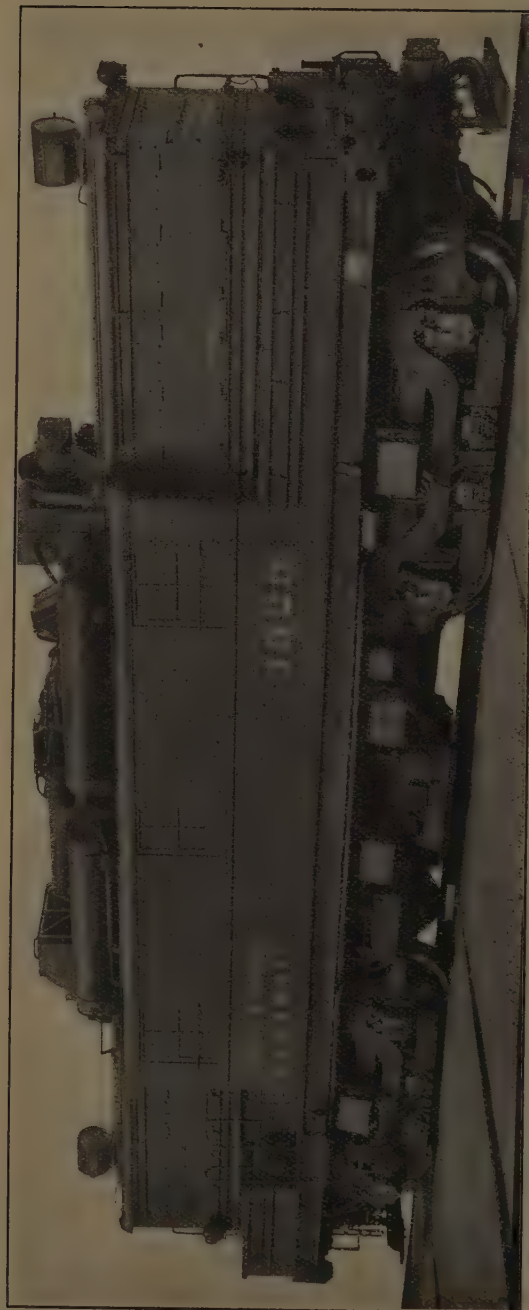


Fig. 13.

American Locomotive Company,  
New York.

Class : 404-0BB-257.

The Electric Storage Battery Co.,  
Philadelphia, Pa.

Built for the New York Central.

General Electric Company.  
Schenectady, N. Y.  
Road number, 4525.

Weight in pounds in working order.		Ingersoll Rand 1-300 H. P. oil engine.		Motors.		Storage battery.	
Total.	Drivers.	Cylinders.	Diam.	Stroke.	Type.	No.	Suspension.
257 000	257 000	6	10"	12"	G. E. 253 A.	4	Spring, Nose.
Capacity.		Gear ratio : 4.24.		Exide iron clad.		Capacity : 294 kw. hours.	
Speed in miles.		Gauge of track 4'8 1/2".		Wheel base.		218 cells.	
Tractive effort, lb.		Internal power.		Driving.		Rigid.	
60 000		External power, trolley or 3rd. rail.		34'-1"		8'-3"	
30 000		3		15		Total	
10 000		9		19		34'-1"	
		16		25		Axles	
						Driving	
						Journal	
						Center	
						8" X 8"	
						44"	
						1580 H. P.	
						Maximum : 40.	

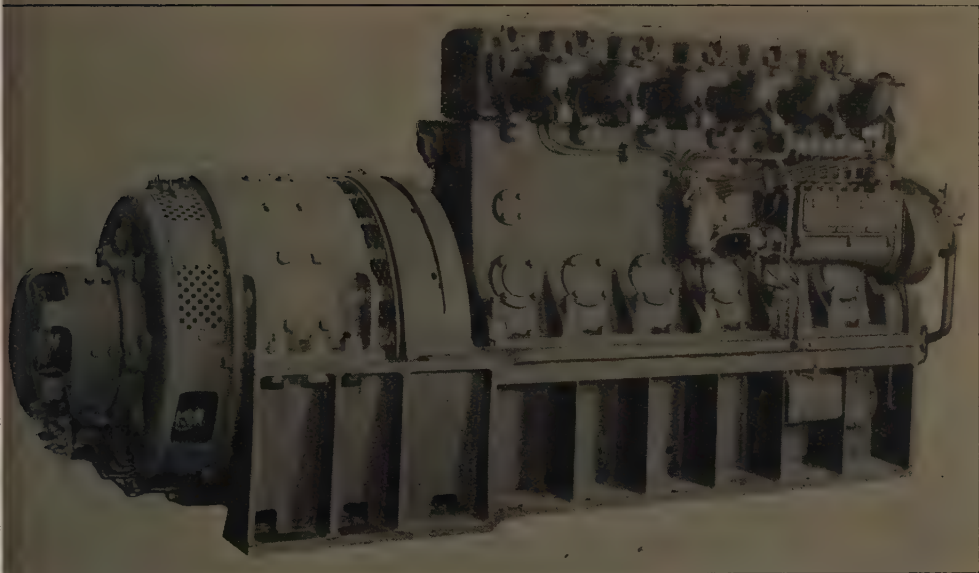


Fig. 14.

supplying power to the motors. At idling speed these operations are performed by the main generator. Each oil-engine and the corresponding generator are supported by a common cast steel bed plate (fig. 14) bolted to the locomotive frame.

The traction motors (two per each unit and four per locomotive) are of the totally enclosed Westinghouse 308-H. type geared to each respective driving axle with a ratio of 4.125. With 38-inch wheels the tractive effort is as shown on figure 15.

The starting of the oil-engines is obtained from two 272 ampere-hour batteries, there being one battery in each cab. A starting controller connects the main generator to the storage battery and accelerates the engine to firing speed. The

oil-engine speed is controlled by a variable speed governor in which a pneumatic piston is incorporated. The air pressure on the piston depends upon the opening of a reducing valve, the setting of which is determined by the position of the handle of the master controller. An air line connecting the two locomotive units permits multiple operation of the two engines. Consequently, each position of the master controller handle causes the two engines to run at a certain speed.

There is in addition an electro-magnetic torque governor which automatically maintains the generator voltage at such a value as to prevent the overloading and stalling of the engine. It also permits automatic transition of the motor connections in each unit from series to parallel.

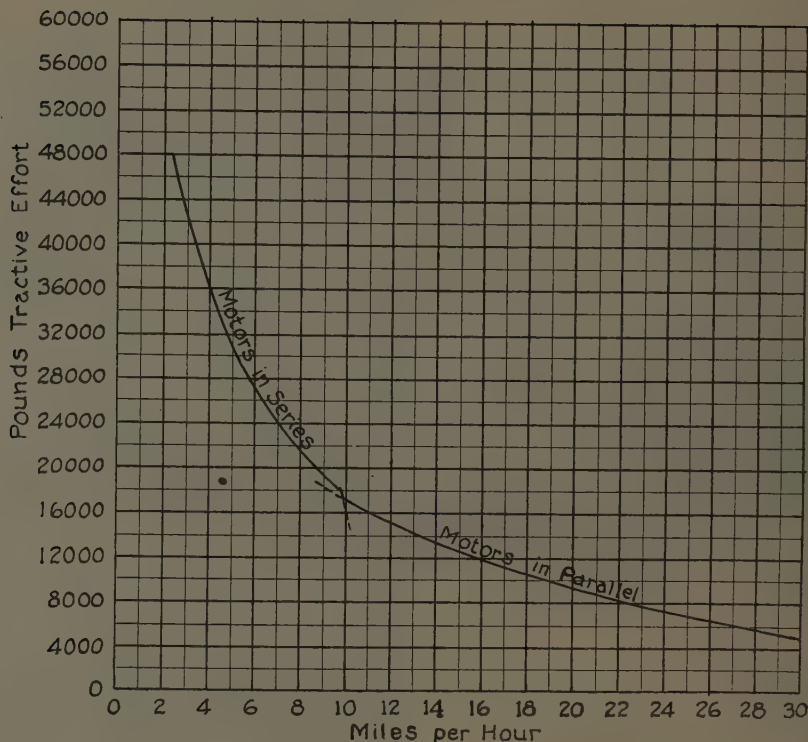


Fig. 15.

The reverse movement of the locomotive is obtained from another handle of the master controller's drum.

The cooling of the water and lubricating oil is obtained from radiators placed on the roof of each unit. Each radiator set is provided with two fans for ventilation driven from one motor.

Figure 16 gives a general view of the locomotive <sup>(1)</sup>.

Type VI. — This is the first road Diesel-locomotive on the American Conti-

nent. It was placed in freight service on the Putnam Division of the New York Central Railroad about the middle of 1928 for handling trains of 300 to 550 tons over approximately 2 % grades. The oil-engine was built by the Ingersoll-Rand Company, the electrical equipment by the General Electric Company, and the mechanical parts—cab, trucks and running gear, by the American Locomotive Company, which also designed the whole locomotive and erected it in their Schenectady Shops. The locomotive is of the 2-D-2 type with 175 000 lb. on drivers and

(1) *Railway Age*, 23 June, 1928, pp. 1451-1454.



Fig. 16.

295 000 lb. total weight. The maximum tractive effort is 52 500 lb. (at 30 % adhesion); the tractive effort on the basis of one hour rating is 30 600 lb. and on continuous rating, 20 800 lb.

The oil-engine is a six-cylinder, 14 1/2-inch bore by 16-inch stroke, four-cycle, single-acting engine with mechanical injection, developing 750 B. H. P. at 500 r. p. m. The design is very similar to that of the 300-B. H. P. engine used on locomotives types I and II. The fuel pump

and the fuel distributor are in principle the same. The engine is started by compressed air from air reservoirs which are kept under full working pressure during operation by a small compressor geared to the engine. In addition, a small outfit is provided which consists of a hand-starting gasoline engine driving a compressor in order to refill the air reservoirs after shut-down periods.

The idling speed of the engine is 240 r. p. m.; the normal speed is 500 r. p. m.;

the maximum speed is 550 r. p. m. Between the idling and the normal speed, five different speeds can be obtained at corresponding positions of the master controller handle which determines the necessary governor setting. This is accomplished in the following way: the fulcrum of a certain lever in the rigging between the governor spring and the fuel pump is dependent upon the position of one of a series of pneumatically operated little pistons, each controlled by a magnet

valve. At each position of the controller handle one definite magnet valve actuates its piston and thus sets the necessary tension on the governor spring corresponding to a certain speed. The amount of fuel delivered by the pump into the the cylinders per stroke is then controlled by the governor at that speed, depending upon the loads. This remote control of the governor and fuel pump makes possible the use of multiple-unit control of two or more locomotives.

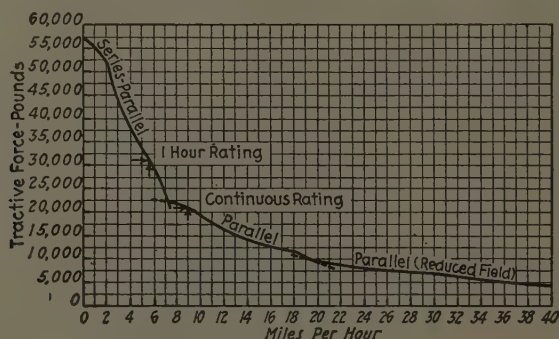


Fig. 17

The main generator is a 500-kw., 600-volt dynamo with eight main and eight commutating poles. The generator has a single bearing on the extreme end, similar to the 200-kw. dynamo of the locomotive type I, but in differentiation from the latter the frame of the generator is rigidly bolted to the locomotive under-frame. The other end of the generator shaft is attached to the oil-engine crank shaft by means of a coupling with axial flexibility. The 250-volt exciter serves at the same time as a small generator for driving auxiliaries.

Four 600-volt, series-wound, single-gear, commutating pole traction motors (GE-286) drive independently four axles

through a 72 : 17 gear ratio. These motors are the same as those used on the storage battery (type IV) locomotive and many other electric locomotives of the New York Central Railroad. Their nominal rating is 340 H. P. at normal voltage. They are provided with motor-driven blowers. The motors can be connected either in series-parallel, or parallel, or parallel with reduced field. The corresponding tractive efforts and speeds are shown on figure 17.

The electric control is slightly modified from that used in the 300-B. H. P. locomotive, type I. The generator has, in addition to the separately excited field and differential series field, a self-excited

shunt field which furnishes the principal energizing of the generator. The separately excited field, which receives current from the auxiliary generator (exciter), is connected in series with a resistance proportioned for each controller step, so that the characteristics of the generator correspond to the required torque of the engine at each speed. Thus at each position of the controller, which determines a certain speed, simultaneously a setting of the field strength is established which is most desirable at that speed.

The main frame is of the usual American bar type with crossties, to which a cast steel underframe is bolted. The underframe supports the oil-engine, the generator, the cab and all auxiliaries. The spring rigging and equalization system have been made as flexible as possible; in addition, springs have been provided for lateral flexibility. The locomotive as a whole has a three-point suspension. The cab has two operating compartments at each end, and a central compartment which accommodates the power plant, and all of the auxiliaries, water and oil tanks, parts of the electric control, etc. The radiators (water coolers) are of the fin-tube type. Cooling air is sucked in through the sides of the cab by two horizontal motor-driven fans, forced through the radiators and discharged through the roof. Brakes are applied to all driving and truck wheels from four 10-inch by 10-inch and two 6-inch by 8-inch cylinders and are operated by compressed air from a motor-driven air compressor having a displacement of 100 cubic feet per minute. A motor-generator supplies a 32-volt auxiliary circuit for lighting and electric control, as well as for charging a 32-volt, 135-ampere-hour storage battery included in the same circuit; the battery provides the lighting when the

engine is not in operation. The air compressor, motor blowers, radiator fans and motor-generator set are supplied with power from the exciter, or auxiliary generator, as it was stated above.

Figure 18 shows the outside view of locomotive (4).

Type VII. — This is the first passenger and the second road Diesel locomotive on the American Continent. It was built for the Putnam Division of the New York Central Railroad and was placed in service early in 1929. The oil engine was manufactured by the McIntosh & Seymour Corporation, the electric equipment by the General Electric Company, and the mechanical parts by the American Locomotive Company. The McIntosh & Seymour Corporation assembled the locomotive in their own shops in Auburn, N. Y. Similarly to the preceding freight, the present locomotive is of the 2-D-2 type with 185 000 lb. on drivers and 361 000 lb. total weight. The maximum tractive effort is 46 300 lb.; the tractive effort on the basis of one-hour rating is 28 000 lb., and on continuous rating, 16 000 lb.

The oil-engine is a 12-cylinder, V-type, four-cycle, single-acting, air-injection engine, with the air compressor on one end and the generator on the other. The cylinders are 14 in. by 18 in. and the engine is rated at 900 B. H. P. at 340 r. p. m. Figure 19 shows the engine. The output of the engine is controlled by the operation of the fuel pump from the master controller. Similarly to the type VI locomotive, by means of a pneumatically operated device with pistons controlled by magnet valves, the position of a control arm is determined by the position of the handle of the master controller. There is no governor however, except an over-

(1) *Railway Age*, 21 July, 1928, pp. 98-100.

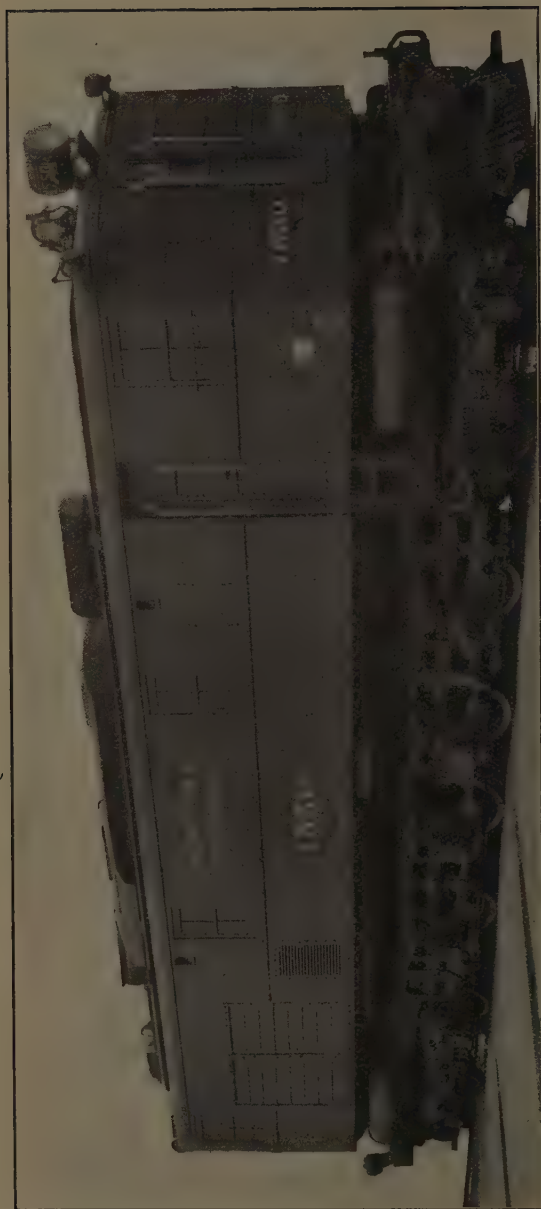


Fig. 18.

American Locomotive Company,  
New York,  
Class 484-OE-301.

Ingersoll Rand Company,  
New York,  
*Built for the New York Central.*

General Electric Company  
Schenectady, N. Y.  
Road number, 450.

Weight in pounds, working order.		1-750-H. P. oil engine.			Motors.				Gauge of truck.	
Total.	Driving wheels	Cylinders.	Diam.	Stroke.	Type.	Number.	Gear ratio.	Suspension.		
304 000	173 000	6	14 1/2"	16"	GE-286 A	4	4 24	Spring, Nose	4'-8 1/2"	
Capacity.					Wheel base.					
Freight service.					Rigid.					Total.
Speed, miles.					17'-6"					42'-10
Starting					Wheel diameter.					Axles.
60 000	28 000	6.2	1-hour rating	Continuous	Driving.	Guiding.	Journal.	Center.	Guiding.	
14 500	40-50	43.2	Max. speed	44"	30"	7' x 14"	7' x 14"	Center.	Journal.	
									6' x 13"	



Fig. 19.

speed governor; and the amount of oil delivered to the fuel pump, and consequently, the torque of the oil engine, depend directly upon the position of the control arm. In other words, the position of the master controller determines the torque of the engine. The speed is then established in relation to the load. The remote control can be extended to another locomotive equipped with a similar engine and pneumatic device by coupling the two devices to the same circuit; this makes possible a multiple-unit control.

The main generator is a 500-kw., 600-volt dynamo, with ten main and ten commutating poles. The generator shaft has two bearings in the generator frame supported by the locomotive frame. The exciter, which also serves as an auxiliary generator, is placed on the extension of the generator shaft; the other end of the shaft is connected with the oil-engine crank shaft by a coupling with torsional flexibility.

The four traction motors are of the same size and type (GE-286) as those used on the preceding locomotive; the gear ratio, however, is different, namely, 69 : 20, in view of the higher speed of the locomotive.

The electric control is the same as that of the preceding locomotive, the controller establishing in each position a certain torque of the oil-engine and the most desirable field strength of the generator at this output.

The design of the frame, underframe, trucks, spring rigging, brakes and of other mechanical parts is the same as that of the preceding locomotive. There is a slight difference in the spring equalization, but the vertical and lateral flexibility have been retained. Likewise, the cab has two operating compartments on

opposite ends of the locomotive. There are two middle compartments accommodating all of the machinery, control and auxiliaries. The smaller of the two compartments contains radiators of the honeycomb flat tube type, manufactured by the Modine Company, the cooling air being sucked in from the sides of the cab by motor-driven fans and discharged through the roof. The brakes and other auxiliaries are of the same general type and character as on the preceding locomotive, the main difference being only in that the passenger locomotive is provided with a boiler for heating the train.

The general view of the locomotive is shown on figure 20 <sup>(1)</sup>.

*Type VIII.* — This is the largest internal combustion locomotive in existence. It consists of two units, of which the first was placed in service on the Canadian National Railways at the end of 1928. Up to 1 July 1929, no information has reached the reporter as to whether the second unit had been completed and placed in service.

Each unit is of the 2-D-1 type, carries its own power plant consisting of a 1 330 B. H. P. oil-engine and generator, and with the equipment and auxiliaries is a complete locomotive in itself. The unit weighs 325 000 lb., of which 240 000 lb. is weight on drivers. With the gear ratio of the electric motor, as first installed in the unit for passenger service, it is capable of developing a tractive effort of 50 000 lb. for a short time, and of 21 000 lb. continuously. With the gear ratio for freight service, namely, 78 : 18, the unit can develop for a short time a tractive effort of 63 000 lb. and even more at starting, up to the limit due to adhe-

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<sup>(1)</sup> *Railway Age*, 23 March, 1929, pp. 663-667.



sion. Some dimensions and data on the whole locomotive (two units) are given in table I.

The first unit was assembled by the Canadian Locomotive Company of Kingston, Ontario; the mechanical design of the locomotive was made jointly by the Canadian National Railways, Canadian Locomotive Company, Baldwin Locomotive Works, Commonwealth Steel Company and Westinghouse Electric and Manufacturing Company, the latter Company having also supplied the generator, motors and electrical equipment. The oil-engines were built by William Beardmore and Co., Ltd. of Glasgow, Scotland.

The engines are of the four-stroke, single-acting, mechanical injection type, each engine developing 1 330 B. H. P. at 800 r. p. m. in twelve cylinders, 12 inches bore by 12 inches stroke, arranged in a V. The engine piston speed is thus 1 600 feet per minute, the same as in the 300-B. H. P. six-cylinder Westinghouse-Beardmore engine of the type V locomotive. Similarly to that engine, the weight of the large Beardmore engine is very low. The engine is of the variable speed type, with idling speed at 300 r. p. m., and is equipped with a governor, the setting of which for any speed between 300 and 800 r. p. m. is controlled electrically from the operating cab. The engine is started by turning the generator as a motor from a storage battery.

The electric control of the locomotive is similar to that of type V locomotive. A torque governor maintains a practically constant torque over the operating range of voltage and current, and prevents overloading and stalling of the oil-engine. The control of the speed of the locomotive is obtained by varying the speed of the oil-engine and shunting the field of the four traction motors. They

are of the series-wound type and are individually geared to the driving axles of the unit. Each unit has one operating compartment, and the locomotive can be controlled from either end by the remote simultaneous operation of generator and motor switches and by speed setting of the engine governors of the two units. The motors are cooled by forced ventilation from motor-driven blowers which can be operated at will when necessary.

The main and truck frames are one-piece castings of the Commonwealth type. The oil-engine bed plate, cab brackets, air ducts, brake hangers and other supports are cast integral with the main frame. The weight equalization is of three-point suspension type, one point being in the center pin of the four-wheel truck, and two other points in the riggings combining springs on each side of all drivers and the two-wheel truck.

The cooling radiators are of the honey-comb type for the oil-engine jacket water, and of the fin-tube type for lubricating oil. The radiators are cooled by air from motor-driven fans of the propeller type and also by natural ventilation resulting from the movement of the locomotive.

The storage battery provided on each unit for starting the oil-engine has a capacity of 340 ampere-hours and is also being used for control, lighting and driving auxiliaries. It is recharged either from the main generator at idling speed, or from the auxiliary generator (exciter) at operating speeds.

The brake equipment of each unit consists of a motor driven compressor, with a displacement of 75 cubic feet per minute, and five brake cylinders, one for the four-wheel truck and four for two groups of two driving axles in each.

Among the auxiliaries is an oil-fired heating boiler for the train, which works

in conjunction with an economizing boiler heated by exhaust gases from the oil engine. An automatic device made dependent upon the pressure in the train heating system controls the fuel-oil supply to the boiler, or cuts it out entirely in accordance with the demand for steam in excess of that delivered by the economizing boiler. When there is no demand for steam at all, the economizer is kept dry and acts as a silencer.

The general appearance of the two-unit locomotive is shown on figure 21<sup>(1)</sup>.

In addition to the described types, there were on 1 July 1929, several locomotives in process of completion or undergoing tests. They have not been placed in actual service yet, and if they should be turned over to a railroad before the end of 1929, information that may become available will appear in a supplement to this Report<sup>(2)</sup>. The most interesting locomotives among them are the 1400 H. P. 2-D-2 locomotive with gear transmission and magnetic clutches now being built by Fried. Krupp in Essen, Germany, for the Boston & Maine Railroad, a 1200-H. P. locomotive under construction at the Baldwin Locomotive Works in Eddiston, Pa., with a Krupp oil-engine and electric transmission, and several locomotives with 300-B. H. P. Westinghouse-Beardmore engines of the type used in locomotive V.

#### D. — Operation of locomotives.

##### a) General.

Replies received from railroads to questions 101-112 of the questionnaire (Appendix III) are to the effect that the swit-

(1) *Railway Age*, 8 December, 1928, pp. 1125-1127.

(2) See Appendix II.



Fig. 21.

ching locomotives (types I to V) are doing work in yards of big cities: The Chicago and North Western operates the three locomotives in the Pier and in Wells and State Street Yards of Chicago; the Reading Company between Willow and Noble Streets and Park Junction in Philadelphia; the Lehigh Valley operates the two locomotives in the yard at West 27th Street and at 149th Street and Harlem River; the Baltimore and Ohio Railroad utilizes the locomotive in its freight terminal, 26th Street and 11th Avenue, in New York City; and so on. The storage battery locomotive of the New York Central (type IV) is doing work in the 60th Street Yard in New York; the freight and passenger locomotives of the New York Central (types VI and VII) are pulling trains on the Putnam Division.

In the majority of cases the crew consists of two men, required by the Interstate Commerce Commission, but practically all railroads operating switching locomotives, except type IV, state that the second man can be dispensed with; in some instances, depending upon local conditions, there is only one man, the operator, in the crew. The Reading Company however, thinks that the second man is required on a switching locomotive to observe clearances on the opposite side from the operator and also to accept signals from the train crew on that side and pass them to the operator.

In the opinion of all railroads, no special training is necessary for a competent steam locomotive driver to operate an oil-electric locomotive. In the majority of cases a ride during one 8-hour shift under the instruction of a qualified operator is sufficient. Ordinarily the road foreman of engines, or one of his assistants, keeps in touch with a new operator

for several days giving further instructions. In other cases two or three 8-hour rides may be necessary. The second man requires no special training other than instructions pertaining to clearances, signals, etc., the same as a fireman on a steam locomotive. The majority of railroads consider that the qualifications of crews are practically the same as for steam locomotives. Only two roads (Chicago & North Western and Great Northern) replied that the qualifications for a Diesel-electric locomotive crew must be higher than those for a steam locomotive crew.

The crews are sometimes assigned to the locomotives more or less permanently, but this is not the rule. In some cases they are changed as often as on steam locomotives; in others not so often. It seems that in all cases the rules of seniority apply.

As to convenience of operation and of control of the oil-electric locomotives, practically all railroads replied that it is more convenient and less complicated. With the automatic control there is only one operating throttle handle for the engineer to manipulate during operation; other handles are for reversing the locomotive, for the application of brakes, for the sander, for ringing the bell, for the whistle, and are used only when required. There are also various switches, like the battery charging switch, the air compressor switch, light switch, air starter button for starting the engine or engines (or electric starting buttons, depending upon the system of starting), a switch or button for stopping the engine or engines, and radiator fan switches, which are used when needed. One railroad (Great Northern) thought the control is convenient but more complicated, as all swit-

ches must be in proper position before starting.

No special handling of the locomotives in the terminals or roundhouses is required. The Lehigh Valley Railroad stated that as a matter of fact the locomotives do not require any attention during the lay-over time (between their working periods), such as is required by steam locomotives. The Delaware, Lackawanna and Western thought that special handling is required until roundhouse forces are qualified to take care of the locomotives. The switching locomotives are refueled and their sandboxes refilled every day in the yard, or in roundhouses, at the end of the day, or between shifts; sometimes during the lunch hour. Water tanks are sometimes refilled every day; sometimes filled once every week. Lubricating oil is changed once in a period from two weeks to two months — in this respect the centrifugal cleaner has been found very useful (See below: Lubrication). Storage battery is charged practically on all locomotives from the generator, or exciter, during operation.

As to the work which the locomotives are able to perform, it varies very much, depending upon local conditions. Locomotives of types I and III usually handle on level track six to twenty cars, approximately up to 700 tons, at a speed of six to eight miles an hour.

On the Reading Railroad locomotives of type I handle two or three cars (approximately 150 tons) on a 5 per cent grade at a speed of about two miles an hour. On the Great Northern Railway, locomotive of type II handles at Minneapolis Junction one hundred empty cars, or 35 cars loaded with wheat (about 2 000 tons) on various grades up to 0.5 per cent.

Locomotive type VI operates freight

trains up to 550 tons on the Putnam Division of the New York Central Railroad, which has a continuous undulated profile with up and down grades up to 1.82 % and 8° curves (700 feet radius). Locomotive type VII is in passenger service on the same division with train of two cars (108 tons) at an average speed of about 23 miles per hour over a distance of 54 miles, with 25 regular stops, and 8 stops on signals, to receive or discharge passengers.

Up to 1 July 1929, no information was available as to the work performed by the 2-D-1 + 1-D-2 locomotive of the Canadian National Railways.

#### b) Fuel performance.

The fuel is usually a Diesel oil with a gravity of 28 to 32° Beaumé. Following is a typical specification used on the Erie Railroad:

Fuel oil shall be a hydrocarbon oil free from grit, mineral acid and fibrous or other foreign matters likely to clog or injure the valves in pumps and nozzles.

Fuel guarantees are based on oil containing 18 500 B. T. U. per pound (effective heat value). Fuel consumption obtained with oils of higher or lower heat value shall be corrected and expressed on the basis of 18 500 B. T. U. oil.

*Carbon residue.* — If the carbon residue is over 0.5 % by Conradson method, a sample of the fuel must be submitted to the Company for approval.

*Water.* — The water content shall not exceed 1 %.

*Sulphur.* — The sulphur content shall not exceed 3 %.

*Viscosity.* — The viscosity shall not be more than 150 seconds Saybolt Universal Viscosimeter at 70° F.

*Flash point.* — The flash point shall not be less than 150° F. (closed cup).

The Delaware, Lackawanna & Western and Baltimore and Ohio Railroads buy oil to a specification which differs from the above in that the sulphur content is not to exceed 1 %. The Long Island is governed by Pennsylvania Railroad's specification 163-A for grade N° 1 winter fuel oil, which stipulates flash point not below 137° F., same viscosity and water content as the Erie, sulphur not over 1 %, and requires a pour test not above 0° F., according to the method of the American Society for Testing Materials. The Great Northern Railway permits a 0.48 carbon residue and requires a flash point of 260° F., presumably in an open cup. The Reading Company stipulates flash points both in an open and closed cup, 200 and 170° F. respectively, no residue, 30° Beaumé gravity, and with various points of distillation. Chicago and North Western requires a specific gravity of 0.8871 to 0.8654, flash point 210° to 230° F., sulphur not over 0.75 %, asphalt and water not over 1 %, and as a stipulation for pour point that oil should be liquid at 0° F. The New-York Central buys oil of a certain brand without any specification, requiring only « extra cold test ».

The oil does not need to be heated in winter, and no changes in the fuel line, injection valves, nozzles, filters, etc., have been found necessary to suit the kind of fuel on any of the railroads, except in cold winter weather on the Great Northern Railway, when hot water coils connected to the cab heater are placed in the fuel tank for heating.

In regard to smoke, the majority of roads reports that under normal conditions there is practically no smoke. Several roads find that the locomotives emit some smoke when the engines are overloaded, or started cold; other rail-

roads think that there is smoke during acceleration periods of the engine, and in all these cases the smoke has a slight grayish haziness. One railroad, which has locomotives with engines of two different types, thinks that both emit a small amount of smoke, during operation, with slight haziness. In another similar case there is in one engine black smoke at full load and rated engine speed, with grayish smoke at idling, and the other engine no smoke at full load and grayish blue at idling speed. One road has always some bluish smoke. The blue tinge in the last two cases would indicate that the amount of lubricating oil was not properly adjusted.

As to consumption of fuel, all available data are collected in table III in reference to switching locomotives. Data on road locomotives (types VI, VII, VIII) are not yet available, nor are they available, for locomotive of type V on the Long Island.

Figures of oil consumption per hour of locomotive operation run very irregularly and no conclusions can be drawn. They depend very much upon local conditions and on the amount of work which is done. The lowest figure is found where the load factor is very low — 5.22 % in this case. Fuel consumption on kilowatt-hour basis does not vary so widely (only between 0.116 and 0.198 U. S. gallon), and whatever variation there is, it is due to the difference in load factor, which varies from 5.22 to 32.7 %. If the load factor were 100 %, the consumption per kilowatt-hour would be 0.08 to 0.09 U. S. gallon depending upon the type of engine and the specific gravity of oil.

As previously stated (see Description of Locomotives), on some types of locomotives there are gasoline driven outfits for

TABLE III  
Consumption of fuel by oil-electric locomotives in America.

RAILROAD (Conventional designation) <sup>(1)</sup> .	SWITCHING LOCOMOTIVES							
	300 H. P. (types I, III and IV).				600 H. P. (type II).			
	Gallons per locomotive- hour.	U. S. gallons per kw.-hour.	U. S. gallons per ton-mile.	Average load factor per cent.	U. S. gallons per locomotive- hour.	U. S. gallons per kw.-hour.	U. S. gallons per ton-mile.	Average load factor per cent.
A (1927 and 1928)	2.24	...	...	...	...	...	...	...
B (1926-27-28)	3.57	0.158	0.60	13.4	...	...	...	...
C (1926-27-28)	3.01	0.164	...	9.1	...	...	...	...
D (1928)	2.98	0.138	...	...	...	...	...	...
E (1926-27-28)	4.23	0.151	...	14.0	...	...	...	...
F (May-Dec. 1928)	4.02	0.126	...	20.0	...	...	...	...
G .	4.37	...	...	...	...	...	...	...
H (1928)	...	0.116	...	32.7	...	...	...	...
K (1926-27-28)	2.07	0.108	...	5.22	...	...	...	...
L (1928)	...	...	...	...	7.12	...	...	...

<sup>(1)</sup> Several railroads requested not to publish their names in connection with expense data and designate them by letters or figures. This necessitated the introduction of a conventional designation for all railroads and for fuel consumption also, as the price of oil is fairly constant.

replenishing the air bottles with compressed air in case the pressure is not high enough for starting the oil engines. The amount of gasoline consumed for this purpose varies from 5 to 69 gallons per locomotive per year, in the latter case amounting to \$8.42 per year. This, of course, is negligible and may be disregarded in comparison with table III. Per locomotive-hour it would represent for this particular road 0.004 gal.

Cost of fuel will be given later with other expenses. (See F. — Cost of operation).

### c) Lubrication.

For the forced lubrication of the oil engine is used a mineral oil of 23 to 26° gravity (Beaumé), made from refined petroleum products. The specifications for lubricating oil require that oil shall be free from acid and water, and shall not contain sulphonates, soap, resin, or tarry constituents, which would indicate adulteration and lack of proper refining. All specifications call for a certain flash point (on some roads to be not lower than 420° F. for paraffin oils and 380° F. for asphalt oils, on others the lower limit is higher, up to 473° F.), for a viscosity at 240° F. (minimum 60 seconds on some roads to 85 seconds on others) and at 100° F. (maximum 600 seconds to 780 seconds), for a cold test, which stipulates that the oil shall pour at a temperature of 45° F. minimum (on some roads the lower limit is 35° F. and on the Delaware, Lackawanna and Western it is 5° F. for asphalt base oil), and for a carbon residue, determined by the Conradson method, not over 0.8 % for paraffin base oils and not over 0.1 % for asphalt oils. The Long Island follows Pennsylvania Railroad's specification, 161-A Heavy, which also stipulates a burning point not

below 529° F., an emulsification test, which should show no emulsification when the oil is shaken with water, nor should there be any precipitation when held at a temperature of 450° F. for 5 minutes. Fat oils are not permitted and free acid equivalent to oleic acid is allowed if not over 0.25 %. The Chicago and North Western does not order lubricating oil to any specification; New York Central buys oil of a certain brand — DTE extra Heavy from the Vacuum Oil Company.

In addition to the forced system oil is used also for lubrication of rocker arms of the engines. The circulating water pump has grease cups for its bearings. Grease is also used on some roads (Baltimore and Ohio, Long Island) for generators (light cup grease), motors, gears (special gear grease), auxiliaries. On other roads (Reading) motor bearings, some of the auxiliaries and their motors are lubricated with oil. Driving axle bearings are always lubricated with ordinary car oil and waste. The Great Northern Railway uses, for instance, the following grades of lubricant:

For the forced system and for rocker arms of the oil engine, Galena motor oil to a specification along the above mentioned lines (gravity 26.7 Beaumé; flash point 435° F.; firing 490°; viscosity at 210° F. 74 seconds; carbon residue 0.48 %).

For generator bearings — No. 5 Star grease Texaco.

For motor bearings — No. 692 and No. 693 Electric car oil Texaco.

For air compressor and blower motors — Alcaid Texaco.

For gears — Calumet compound.

For axle bearings — Car oil Texaco.

Carbonization and dilution of engine lubricating oil in some cases becomes noticeable very quickly, probably depend-

ing upon the kind of oil. New York Central states that carbonization becomes noticeable as soon as the oil engine starts. Other roads begin to observe carbonization in a period from one to six weeks. In one case a road states that carbonization and dilution have been stopped since the brand of oil was changed. Chicago and North Western, Long Island and Delaware, Lackawanna and Western are of the opinion that filters do not completely remove carbonization. Two railroads (Reading and Great Northern) removed the filters from locomotives altogether; others (New York Central and Long Island) replaced them by centrifugal separators which seem to give very good results; oil is kept cleaner and in better condition and can be used for a longer period without changing; the centrifuge is more easily cleaned than the filter and occupies less space in cab. The Long Island ascribes to the centrifugal separator such advantages as longer life of engine bearings, longer periods between repairs, better engine performance and longer engine life. In addition to the above mentioned railroads, centrifugal separators are used on Illinois Central, Hoboken Manufacturers Railroad and on some industrial locomotives like Donner Steel Co.

As to lubricating oil consumption, the figures vary widely, as it was in the case of fuel consumption, namely, from 0.037 to 0.140 U. S. gallons for a 300-B. H. P. engine per hour. It should be remembered that the load factor is low (see table III). Cost of lubrication will be given later with other expenses (see F. — Cost of operation).

#### d) Cooling.

Practically all locomotives now have fan-blown radiators (coolers) for cooling the jacket water of the oil engine and the

lubricating oil. The design of the system has been given in the description of locomotive types. Some of the first switching locomotives had radiators without fans, depending only upon natural air circulation, but most of them have been rebuilt.

The amount of water needed for replenishment due to evaporation and losses is very small. It fluctuates from 8 to 20 U. S. gallons a day for a 300-B. H. P. engine. One railroad even placed its consumption as low as 2.5 gallons a day. The cost of the water is, of course, negligible, but in some cases it is given with other expenses (see F. — Cost of operation).

No pitting of cylinder jackets, liners and cylinder heads has been observed by railroads, except in one case, on the New York Central on the storage battery locomotive. It is being taken care of by frequent washing of the system.

#### e) Heating.

All locomotives, except the storage battery locomotive of the New York Central, have heaters (see C. — Description of locomotives); practically in all cases they are small coal burning water heaters with radiators in the operating compartments. The passenger locomotive of the New York Central Railroad (type VII) has a large heater for heating the train.

In all cases the heaters are connected with the cooling system by means of valves. In cold weather, during lay-over periods, when the engine is not operating, the valves are opened in order to connect the cooling system with the heating system and prevent freezing.

#### E. — Inspection and repairs.

Replies received to the questions on inspection and repairs are of a greater variety than those previously reported.

It was not deemed advisable to review them in a general way as it was done in the preceding chapters, and it was preferred to tabulate the replies, quoting them verbatim. They are given below pages 904 et seq., and when a note was thought necessary, it was put in brackets, followed by two initials of the author (A. L.).

From the perusal of the replies it will be seen that no great difficulties have been experienced so far with the proper maintenance of the locomotives or their parts. As regards the oil-engine, on one road only one engine crank shaft broke on account of the running speed being too close to the critical speed. The speed has been reduced to 550 r. p. m. without changing the output of the engine — the mean effective pressure was raised correspondingly without difficulty. The same change has been made on engines of this type on other roads, and no further trouble has been experienced since.

Some difficulties were encountered with generator and motor armatures which were burned out, as shown in the tabulation. A few of these cases were accidental; others were due to design, and after some changes in design and methods of operation had been made, no difficulties were experienced.

In a few cases some difficulties arose with the circulating pump, fuel pump and other auxiliaries, as given in detail in the tabulation, but they all referred to small matters which were easily repaired. The principal parts such as the oil-engine, generators and motors, proved their suitability to the service for which they were designed and nothing in these parts was discovered of a character which would prevent the locomotives from giving satisfaction. It will be observed that as more and more locomotives were placed

in service, cases of broken parts or burned out motors became fewer.

In order to indicate the length of time to which the tabulated repairs refer, the dates of placing the locomotives in service on railroads and the dates of their replies are given in table IV.

#### F. — Cost of operation.

Data received from railroads in reply to questions 113, 125, 126, 138, 139, 142, 153, 198, 205, 213, 223, 234, 244, 245 and 246 are compiled in table V. The information is far from being complete, and the table represents the best general summary which the reporter was able to prepare from the available data.

The term of service of road locomotives (types VI-VIII) and of some switching locomotives (IV-V) had been so short that railroads were unable to give out any information on these locomotives. One road remarked that their experience had been so different from what they thought it would be after the operation and maintenance of the locomotives had settled down to a routine, that the data that they might have communicated would be misleading. The received information turned out to pertain exclusively to switching locomotives (types I-III), with which the railroads had already had experience during several years. Roads A-K reported on locomotives of 300 H. P. output (types I and III), although one of them had also 600-H. P. locomotives (type II); roads K and L sent data on these latter locomotives.

A brief review of table V might be of use to the reader. The first column gives the conventional designation of railroads. This was necessary because two roads of the ten, which sent in operation cost data, specifically requested that the name of

Item.	NAME OF RAILROAD.	Total number of locomotives.	Types of locomotives.							Date of Railroad's reply.
			I.	II	III	IV	V	VI	VII	
1	Baltimore & Ohio . . .	1	January 1925	...	...	...	..	...	..	4 April 1929
2	Lehigh Valley . . .	2	January 1926	...	April 1927	...	...	...	..	6 April 1929
3	Long Island . . .	3	...	February 1926 October 1928	...	...	May 1928	...	...	20 March 1929
4	Great Northern . . .	1	...	November 1926	...	...	...	...	...	10 May 1929
5	Chicago & Northwestern .	3	May 1926 October 1926 April 1926	...	...	...	...	...	...	29 May 1929
6	Reading . . .	2	April 1926 March 1928	...	...	...	...	...	...	6 March 1929
7	Delaware, Lackawanna & Western . . .	2	July 1926 July 1926	...	...	...	...	...	...	29 March 1929
8	New York Central . . .	3	...	...	...	February 1928	...	...	..	13 April 1929
9	Illinois Central . . .	1	March 1929	...	...	...	...	July 1928	March 1929	11 Sept. 1929
10	Hoboken Manufacturers' .	2	January 1929 January 1929	...	...	...	..	...	...	20 Sept. 1929
11	Donner Steel Co. . .	4	April 1928 January 1929 (3 locom.)	...	...	...	...	...	...	22 March 1929

Number of questions listed in the questionnaire	QUESTIONS.	Answers	
		Baltimore & Ohio.	Lehigh Valley.
154	Is the main engine of the locomotive periodically inspected independent of repairs and how often?	Yes, once each week.	Main engine is given a daily inspection.
155	Are the auxiliaries and other parts of the locomotive periodically inspected and how often?	Yes, once each week.	Parts of the locomotive given a daily inspection.
156	Have there been any serious repairs or replacements of parts of engine generator, motors, and other locomotive parts which required laying off a locomotive for more than a week? Describe the nature of repairs.	No.	We have had one case of armature burned out on a generator which was repaired by the General Electric Company.
157	Were the heavy repairs of the preceding item accidental, or were they regular results of the design and service of the locomotive?	No heavy repairs.	Cannot state.
158	Have the causes of the heavy repairs been eliminated and how?	...	As far as possible.
159	What kind of repairs require laying off of a locomotive for more than a day?	General inspection.	General repairs and cleaning.
160	What is the average number of hours per month a locomotive is out of service due to inspection and repairs?	None.	For the calendar year engine No. 100 (type I-A) was out of service approximately 1 1/4 h. per month. engine No. 125 (on which generator armature was burned out — type III-A) approximately 56 1/4 h. per month. Number of locomotives out of service for locomotive No. 125 is mainly due to generator armature being in the shop awaiting return of burned out armature, referred to as item 156.
161	What is the average number of hours of service per locomotive per month?	288.5.	Average number of hours of service per month was 288.5 for calendar year 1928: 167.5 hours for locomotive 125 (Type I) and 167.5 hours for locomotive 125 (Type A. L.).

## m Railroads.

<i>Long Island.</i>	<i>Great Northern.</i>	<i>Chicago and North Western.</i>
... 30 days.	Yes, weekly.	Yes, at six-month intervals, which are being extended to nine months.
... 30 days.	Yes, weekly.	Yes, weekly.
... one locomotive (No. 101) considerable repairs were necessary to engine equipment. Broken crankshaft necessitated dismantling entire engine (see below).	Yes, generator armature on account of air duct spacers thrown out. Connecting rods and main bearings of oil engine changed by builders. One set of main bearings was burned out due to oil plug coming out and losing oil.	Yes, one generator armature burned out. Also repairs of pistons and loose wrist pins.
... answer received—A. L.)	Burning out of bearings accidental. Rest of changes was made due to design.	Regular results of the design and service of the locomotive.
...	Yes, by change of design.	...
... information not available.	Closing connecting rod bearings and main bearings.	Annual inspection, grinding valves, etc.; truing up commutator, turning tires.
...	280 hours per month.	227.9 hours per month.
...	400 hours per month.	492.0 hours per month.

Number of question as listed in the questionnaire.	QUESTIONS.	Answers.	
		Baltimore & Ohio.	Lehigh Valley.
162	What is the balance of the total number of hours per month and those of items 160 and 161 due to fueling, sanding, storing, Sundays, holidays? How many hours are due to each of these causes?	Engine works six days per week. Inspection is made when engine is idle. Fueling, sanding is done during twenty-minute lunch period by laborer.	The balance of the total number of hours per month is due to Sundays and holidays during which time the engine is not operating.
171	Have you had cases of broken crankshafts, cylinders, cylinder liners, cylinder heads, pistons, connecting rods and other heavy parts? What were the causes of the breakages? Have they been removed?	No.	We have had no cases of broken crankshafts, etc.
172	Were the above parts replaced or repaired, and if repaired, how was it done?	No broken parts.	No broken parts.
173	How long was the locomotive out of service each time?	No broken parts.	...
174	Can all other repairs be classed as « running repairs »? If not, enumerate those which cannot.	Yes.	Yes.
175	How many miles (or how many hours) does a locomotive run before the crank shaft bearings or crank pin bearings require adjustment—taking out shims, replacement of shells? Indicate whether shells, lined with white metal, are of steel or bronze.	About 900 hours for taking out shims. Wrist pin bearings are of steel and lined with bronze. Crank pin bearings are steel lined with white metal.	About six months to one year. No definite data available. Both steel and bronze shells are used.
176	What is the average wear of bearings on time or mile basis?	900 hours approximately (between babbitting?—A. L.).	No data available.
177	What is the average wear of journals and pins?	Not available.	...
178	What is the average wear of pistons?	...	...
179	What is the average wear of piston rings?	...	...

## Railroads.

<i>Long Island.</i>	<i>Great Northern.</i>	<i>Chicago and North Western.</i>
...	Fueling and sanding 7 hours; off the job 34 hours per month.	None.
Broken crankshaft on one of the locomotives. Speed reduced from 600 to 550 r. p. m. in order to discontinue operating at critical crankshaft speed. Cylinder heads cracked from overheating when circulating water pump failed. Supply tanks were elevated to insure positive delivery of water to engine.	No.	...
were replaced.	None.	...
Approximately 2 months were necessary to make replacement, repairs and change in the cooling system.	None.	...
	Yes, only on periodical inspections when engine was taken to shops for repairs, and inspections were made for wear and tear.	...
Approximately 1 000 hours. Bearings shells are of steel and lined with white bearing metal.	900 hours. Bearings replaced only when shopped and when found thin, using white metal for bearing lining.	...
Information not available.	On 900 hours, wear from 0.003 to 0.008 inch.	For 5 000 to 6 000 hours, 0.003 inch wear on diameter.
...	Unable to give definite figures.	None determined.
...	0.005 inch in 26 months of service.	Approximately 0.017 inch (in 5 000-6 000 hours. — A. L.).
...	Average wear impossible to measure on account of being a segment ring, but they have to be replaced about every 12 months.	Not determined.

Number of question as listed in the questionnaire	QUESTIONS.	Answers	
		Baltimore & Ohio.	Lehigh Valley.
180	What is the average wear of cylinders or cylinder sleeves (liners)?	...	...
181	When and how often are piston rings replaced on account of wear? What percentage of piston rings break within a certain time (six months)? What is the average life of rings?	Engine has made 64 830 miles with no replacement of piston rings.	We have not replaced any piston rings for wear; a few have been replaced on account of being broken for removal.
182	What is the average wear of wrist (gudgeon) pins, and their bearings?	Wear on wrist pins not available. On bearings, shims renewed every 5 to 6 months.	No data available.
183	Is wear in piston grooves noticeable, and how is this being taken care of?	Not noticeable after 3 years of service.	We have not noticed any wear in piston grooves.
184	When are pistons replaced?	No replacements made in 3 years of service.	Pistons have not been replaced.
185	Have any advantages been found in the split - skirt - constant - clearance pistons with respect to maintenance of cylinders, pistons, piston rings and other parts?	Pistons have solid skirts.	Neither of our engines is equipped with split-skirt-constant clearance pistons.
186	What difficulties have been experienced with valves in cylinder heads? How have they been remedied?	None.	We have not experienced any difficulty with these valves.
187	How often must intake and exhaust valves be ground? When and how often are they replaced?	Once every six months to insure perfect compression.	Approximately each six months. None have been replaced.
188	Are valve cages being replaced? If seats are direct in the cylinder heads, are replacement seats inserted?	There are no valve cages. Seats are cast integral with the heads.	A few of our valve cages have been replaced on locomotive No. 125 (Type III-A.L.). No replacement seats have been inserted.
189	Do valves get stuck? What are the causes and remedies? Of what material are guides for valve stems made? Have special bronze guides for valve stems been tried?	Occasionally when they get dry. Plain fuel oil remedies the trouble.	We have not experienced trouble with sticky valves. Guides and valve stems are made of steel. Special bronze guides are not used.

## Railroads.

<i>Long Island.</i>	<i>Great Northern.</i>	<i>Chicago and North Western.</i>
...	Cylinder liners wear 0.002 inch. in 26 months.	Approximately 0.0044 inch in 2 years.
Record available. Excellent service thus far on locomotives 401 and 402 (type II. — A. L.).	Every 12 months; 1 % at least in 12 months.	Two years. Approximately two years.
Visible on all 3 locomotives.	Not noticeable. Slightly on brasses.	Two years show 0.0015 inch wear.
Not noticeable on locomotives 401 and 402.	Yes. True up grooves and fit oversized rings.	Yes. By cleaning grooves apply oversized rings.
Replaced on locomotives Nos. 401 and 402. On No. 403 (type V. — A. L.), piston renewed when sufficient wear develops.	Not replaced in 26 months of service.	When wrist pin wear is excessive.
Used.	We have not used anything but solid cast iron trunk type pistons.	Solid pistons are used.
Wear — due to carbon deposit forming on valve stem and guides. Seizure occurs after engine has cooled down. No permanent remedy available. Valve stems and guides cleaned and replaced.	Have had no trouble with valves except sticking occasionally. By pouring kerosene on valve stem.	Pitted seats. Maintain strong springs.
Annual inspection. Seldom replaced.	Ground in every six months. Replaced four valves in 26 months.	Five to six thousand hours. Still in service.
Replacement seats or cages. Seats correct in head.	Not used. No solid head.	No valve cages.
Caused by carbon deposits. No permanent remedy available. Valve guides are made of cast iron on locomotives 401 and 402, and of bronze on locomotive 403 (see above, A. L.).	Occasionally, from not oiling them. Valve guides are made of cast iron. Have not used bronze or brass.	Yes. Insufficient clearance; increase clearance; cast iron. No.

Number of question as listed in the questionnaire	QUESTIONS.	Answers	
		Baltimore & Ohio.	Lehigh Valley.
190	<i>How often do valve springs break? What is the average life of a valve spring?</i>	Have broken eight springs in three years service. Last one failed more than a year past.	We have had no cases of broken valve springs.
191	<i>What difficulties have been experienced with fuel valves and sprays? How often are they inspected? When and how often are they replaced?</i>	None.	Have not experienced difficulties with fuel valves and sprays. Inspected at about six-month intervals. None replaced.
192	<i>Are rubber seal rings used at the bottom of the water jacket (when the cylinder liner is removable)? Do they give trouble? How is the trouble being remedied?</i>	Not used.	Rubber seal rings are not used.
193	<i>Has any corrosion of steel parts in the crank case been observed? How is this being eliminated?</i>	None.	Corrosion of steel parts in crank case has not been observed.
194	<i>Has any difficulty with lubrication been met with? How has it been cured?</i>	None.	We have not experienced difficulty with lubrication.
195	<i>What is the experience with the fuel, lubricating oil and water circulating pumps? Which parts require renewal and how often?</i>	We have not experienced any trouble.	We have not experienced particular trouble.
196	<i>What is the wear of the fuel pump plungers? When and at what intervals are they being replaced?</i>	Not available.	No data available.
197	<i>What material is used for the strainers in the fuel oil and lubricating oil filters? How often is this material renewed?</i>	Fuel oil — Monel metal screen. Lubricating oil—cloth bag filter and fine copper strainer, renewed when bags are torn, about every thirty days.	...

## railroads.

<i>Long Island.</i>	<i>Great Northern.</i>	<i>Chicago and North Western.</i>
Failures recorded.	Replaced one valve spring in 26 months.	Failures not frequent.
Failures have been experienced in fuel valves and sprays. Inspected every 30 days on locomotive No. 403 (see above, A. L.) and repaired only when out of order (on locomotives 401, 402).	Nothing but gumming up. Every six months. Did not replace any.	Slight leakage after approximately six months operation. Inspection every six months. Spray nozzle checked reground in 12 months. None replaced to date.
Water liner not used on locomotives Nos. 401 and 402, and on locomotive No. 403, where used, no trouble experienced.	Water jacket cast with cylinder. No sleeves or rubber seals used.	None used.
	No.	No corrosion.
	Yes, due to fuel oil leaking into crank case caused by overflow from injection pump being plugged up. Put in larger overflow.	Yes, pipe lines breaking; by more frequent inspection.
Locomotive No. 401 fuel pump seized; broken coupling to circulating oil pump between drive and pump. Circulating water shaft broken. On locomotive No. 403 trouble experienced with pump which developed leakage. A portion of pump was replaced and leakage eliminated. Trouble experienced on the third locomotive.	Have not renewed any.	Fuel and lubricating pumps, blow gaskets and shear coupling key. Coupling trouble remedied by redesign of coupling. Water pump breaks shafts occasionally. Pump design changed. No trouble experienced since.
	None noticed. Replaced one due to some metal getting into plunger cylinder.	None noticeable. Changed frequently due to sticking.
Monel metal wire gauze filters are used in lubricating filters.	None replaced on the fuel oil. No filters used on lubricating oil.	250 mesh wire (per 1 sq. inch — A. L.) used for fuel oil strainer. None changed out yet. Flannel bags used in lubricating oil filters. Renewed eight times a year.

Number of question as listed in the questionnaire	QUESTIONS.	An	
		Baltimore & Ohio.	Lehigh Valley.
201	At what intervals is the inspection of electric equipment (brushes and commutators of generators and motors, relays, storage batteries, etc.) made?	Once each week.	Inspection of electric equipment is made weekly.
202	Have difficulties with commutation been experienced, and how were they remedied?	None.	We have not experienced difficulties with commutation.
203	Have there been cases of overheating of motors, and what were the results?	None.	We have not had cases of overheating.
204	Do the storage batteries require additional recharging, and how is this being done?	Not required.	We have not had occasion to recharge the storage batteries, as these are kept charged by the generator.
211	Have any difficulties been experienced with the air compressor, starting outfit, radiators, heaters, sanders, etc.?	None.	No.
212	How often are the apparatus enumerated in the preceding item inspected?	Once a week.	Parts are inspected daily.
221	State in which respect are mechanical parts of internal combustion locomotives inspected and repaired differently from mechanical parts of other locomotives.	No difference.	Practically the same conditions exist in regard to inspection and repairs.
222	Is the wear of mechanical parts different from that of ordinary locomotives? If so give comparative figures.	No.	The wear of mechanical parts should not differ greatly from that of ordinary locomotives.

## Railroads.

<i>Long Island.</i>	<i>Great Northern.</i>	<i>Chicago and North Western.</i>
30 days.	Once a week.	Weekly inspection.
	Flashing of main generator cleaned up with sand paper.	Yes, in main generator. Changed winding of interpoles.
	None.	None experienced.
	Very little charging done in round-house.	No.
Difficulty, except on one locomotive the starting air compressor causes the starting valve to stick.	No.	Difficulty experienced with radiator of straight tube type due to freezing. Trouble experienced with starting air compressor engine due to breaking valves.
30 days.	Once a week.	Weekly.
difference.	No difference.	A general inspection of piston, connecting rods and cylinder is made every six months which is not common to a steam locomotive.
	No difference.	Cylinder wrist pin and connecting rod.

Number of question as listed in the questionnaire	QUESTIONS.	ANSWERS.	
		Reading.	Delaware, Lackawanna & Western.
154	Is the main engine of the locomotive periodically inspected independent of repairs and how often?	Yes, every week, month, or year, depending on the part to be inspected. Every part is inspected at least once a year.	Yes, inspected every two weeks.
155	Are the auxiliaries and other parts of the locomotive periodically inspected and how often?	Same as above.	Inspected every two weeks.
156	Have there been any serious repairs or replacements of parts of engine generator, motors, and other locomotive parts which required laying off a locomotive for more than a week? Describe the nature of repairs.	Two armatures on generator burnt out, insulation knocked off exciter armature, traction motors burned out, and radiator header cracked.	None.
157	Were the heavy repairs of the preceding item accidental, or were they regular results of the design and service of the locomotive?	First case with generator armature and exciter armature was accidental.	None.
158	Have the causes of the heavy repairs been eliminated and how?	Yes; by using more care when barring over oil engine, by putting collar on shaft, using mica insulation and cast iron radiator header instead of aluminium.	None.
159	What kind of repairs require laying off of a locomotive for more than a day?	Trouble with auxiliary air compressor for starting, broken traction motor pinion gear, broken fuel oil distributor shaft, renewing wheels, and things mentioned under No. 156.	Overhauling Diesel engine generator repairs, truck repairs, wheel turning.
160	What is the average number of hours per month a locomotive is out of service due to inspection and repairs?	180 hours.	41.2 hours for heavy repairs.
161	What is the average number of hours of service per locomotive per month?	421 hours.	152.1 hours.
162	What is the balance of the total number of hours per month and those of items 160 and 161 due to fueling, sanding, starting, Sundays, holidays? How many hours are due to each of these causes?	119 hours, waiting to be called.	Fueling, sanding is being done during service hours; starting 420 hours per month; Sundays 100 hours; holidays 16.7 hours.

Railroads.			
<i>New York Central.</i>	<i>Illinois Central.</i>	<i>Hoboken Manufacturers'.</i>	<i>Donner Steel Co.</i>
daily for adjustments of defects; monthly — thorough inspection and checking of bearings, clearances, etc.	Inspected once each week and is held in on Monday for this inspection.	Every day one hour; every seven days general inspection.	Yes; each week.
inspected daily; cleaned and inspected monthly.	Same as main engine.	Same as above.	Yes; each week.
...	No.	No.	No.
...	No.	None.	...
...	Had none.	None.	...
sufficient service to answer this question.	Have had none so far as engine is not in service a sufficient length of time and only out for minor accidents, incident to handling a new type of power.	Have had no reason for laying off locomotive for a day outside of Sundays.	Repairs necessary through accident.
ge battery locomotive (type IV) : 88 hours.	86.3 hours.	Four Sundays a month.	20 hours.
locomotive 619 hours.	640 hours.	350 hours a month.	700 hours.
...	...	12 hours a month for fueling and sanding.	Out of 24 hours per day for 30 days, sanding, inspection and running repairs require 20 hours.

Number of questions listed in the questionnaire	QUESTIONS.	Ans.	
		Reading.	Delaware, Lackawanna & Western.
171	Have you had cases of broken crank-shafts, cylinders, cylinder liners, cylinder heads, pistons, connecting rods and other heavy parts? What were the causes of the breakages? Have they been removed?	Cracked combustion chamber. Water pump impeller loose on shaft. Yes.	None of enumerated parts placed due to breakage.
172	Were the above parts replaced or repaired, and if repaired, how was it done?	Replaced.	None replaced.
173	How long was the locomotive out of service at each time?	Nine days.	No time out of service on account.
174	Can all other repairs be classed as « running repairs »? If not, enumerate those which cannot.	Yes.	Yes.
175	How many miles (or how many hours) does a locomotive run before the crank shaft bearings or crank pin bearings require adjustment—taking out shims, replacement of shells? Indicate whether shells, lined with white metal, are of steel or bronze.	14 000 miles; steel shells lined with white metal.	Once each 1 500 hours of vice by taking out sh steel shells lined with bal
176	What is the average wear of bearings on time or mile basis?	No data.	Average wear 0.003 inc. 1 500 hours of service.
177	What is the average wear of journals and pins?	No data.	Not available.
178	What is the average wear of pistons?	Negligible.	...
179	What is the average wear of piston rings?	...	...

## railroads.

<i>New York Central.</i>	<i>Illinois Central.</i>	<i>Hoboken Manufacturers'.</i>	<i>Donner Steel Co.</i>
	None.	No. Cracked crank pin bearings. Yes.	No.
	None.	Replaced with new ones.	...
...	None.	Work done on Sundays and when locomotive was stored.	...
battery locomotive; repair of fuel oil pump shaft and butor valve.	Yes; running repairs.	Yes.	Yes.
type IV — main bearings were adjusted twice in first two months. Three months they were adjusted. No further adjustment in last 7 months of first year of operation. Locomotives types and VII — not sufficient service.	No adjustments to date on crank pin or crank shaft bearings necessary.	1 000 hours. Shells of steel lined with white metal.	4 200 hours. Shells are of steel.
type IV — main bearing 0.0015 inch, connecting rod bearing 0.003 inch in 4 800 hours locomotive service. Not sufficient experience with locomotives.	No record — bearing in good condition.	About 0.003 inch every 1 000 hours.	25 000 miles calculated on 6 miles per hour switching service (between taking out shims? — A. L.).
roads.	No record — journal in good condition.	Do not know — have had no cause to renew.	From 0.008 inch to 0.010 inch in 4 200 hours of service.
as available; engine not been dismantled.	No record — pistons in good condition.	...	Have noticed no wear to date.
...	No record — piston rings in good condition.	...	...

Number of question as listed in the questionnaire	QUESTIONS.	A.	
		Reading.	Delaware, Lackawanna & Western.
180	What is the average wear of cylinders or cylinder sleeves (liners)?	...	...
181	When and how often are piston rings replaced on account of wear? What percentage of piston rings break within a certain time(six months)? What is the average life of rings?	Once a year. 17 %. Ten months.	None replaced on account of wear. Not available.
182	What is the average wear of wrist (gudgeon) pins, and their bearings?	No data.	Not available as to pins, rings 0.003 inch in hours.
183	Is wear in piston grooves noticeable, and how is this being taken care of?	Yes in firing ring grooves. Return grooves.	Yes;; average about 0.003. Not sufficient to be care of since engine placed in service.
184	When are pistons replaced?	Not necessary to date.	None replaced since engine placed in service.
185	Have any advantages been found in the split-skirt-constant-clearance pistons with respect to maintenance of cylinders, pistons, piston rings and other parts?	Not used.	Solid skirts in use on engine.
186	What difficulties have been experienced with valves in cylinder heads? How have they been remedied?	Pitted exhaust valve. Used nickel-chrome valves.	No difficulty experienced to date.
187	How often must intake and exhaust valves be ground? When and how often are they replaced?	Once a year.	Ground on average once a year; none replaced to date.
188	Are valve cages being replaced? If seats are direct in the cylinder heads, are replacement seats inserted?	None to date.	Valve cages not used. Seats are direct in heads. No difficulty experienced to date.
189	Do valves get stuck? What are the causes and remedies? Of what material are guides for valve stems made? Have special bronze guides for valve stems been tried?	Yes; carbon on valve stems, causing valves to stick in guides. Remedied by applying kerosene. Steel. No.	Yes, valves occasionally get stuck from carbonization and are removed by application of kerosene. Guides of stems are of cast iron. Bronze guides have not been tried.

## on Railroads.

<i>New York Central.</i>	<i>Illinois Central.</i>	<i>Hoboken Manufacturers'.</i>	<i>Donner Steel Co.</i>
...	No record — cylinders in good condition.	...	...
...	No replacement to date for wear or breakage.	...	Have no information to date.
...	Wrist pins and bearings are in good condition.	...	About 0.006 inch in 4200 hours of service.
No data available; engine has not been dismantled.	No noticeable wear in piston ring grooves.	No.	Not noticeable to date.
...	No piston replacement to date.	When worn or broken.	Have no information to date.
...	None to compare with, as we have only one engine.	...	Have no split shirt on piston. Piston is solid.
No difficulty except as covered under No. 189.	None to date.	None to date.	None.
No valves ground or replaced yet.	None ground to date.	None.	Ground after 10 000 hours of service; no valves replaced to date.
No cages on locomotives types IV and VI. On locomotive type VII no cages replaced; no replacement seats.	None to date.	None as yet.	Seats are in cylinder heads and cannot be replaced.
On type IV valves stuck when new, not sufficient clearance; normal wear relieved condition. Guides of cast iron. On type VII, guides of bronze; valves stick due to carbon deposits; often remedied by applying kerosene. On type VII valves do not stick.	No. Guides are of bronze, stems are of steel.	No. Cast iron.	When new engine is put in service, exhaust valves occasionally stick due to close clearance and expansion of valve stem before it has seated.

Number of question as listed in the questionnaire	QUESTIONS.	Answer	
		Reading.	Delaware, Lackawanna & Western.
190	How often do valve springs break? What is the average life of a valve spring?	Only two broken valve springs in two years.	No difficulty experienced with valve spring breaking. Average life data not available.
191	What difficulties have been experienced with fuel valves and sprays? How often are they inspected? When and how often are they being replaced?	Leak. Whenever oil engine smokes.	No difficulty experienced. Inspected each six months. None replaced.
192	Are rubber seal rings used at the bottom of the water jacket (when the cylinder liner is removable)? Do they give trouble? How is the trouble being remedied?	Not used.	Cylinder liners not used.
193	Has any corrosion of steel parts in the crank case been observed? How is this being eliminated?	No.	No corrosion observed to date.
194	Has any difficulty with lubrication been met with? How has it been cured?	Excessive use of oil; changed grade.	No difficulty experienced with lubrication.
195	What is the experience with the fuel, lubricating oil and water circulating pumps? Which parts require renewal and how often?	None to date.	No difficulty experienced.
196	What is the wear of the fuel pump plungers? When and at what intervals are they being replaced?	No data. 2 years.	No difficulty experienced; none replaced.
197	What material is used for the strainers in the fuel oil and lubricating oil filters? How often is this material renewed?	Copper screens, two years.	Fuel oil lubricator has Mon metal strainers; not replaced. Lubricating oil filter has flannel bag strainers; replaced each six months.
201	At what intervals is the inspection of electric equipment (brushes and commutators of generators and motors, relays, storage batteries, etc.) made?	Once a week.	Once each month.
202	Have difficulties with commutation been experienced, and how were they remedied?	None.	No difficulty experienced.
203	Have there been any cases of overheating of motors, and what were the results?	Yes: burned out armatures.	No overheating of motors experienced.

Railroads.			
<i>New York Central.</i>	<i>Illinois Central.</i>	<i>Hoboken Manufacturers'.</i>	<i>Donner Steel Co.</i>
broken to date.	No breakages to date, so no life can be given.	Never had any broken.	Have had no valve springs broken. No information to date.
every three months; replacements.	No difficulties; no replacements; inspected each week.	Have had none; inspected monthly.	None; every six months.
on type VII. No trouble.	None used. No removable liner in cylinder.	...	Cylinders are cast integral; no liners.
	No corrosion to date.	None.	No.
on locomotives types and VII. On locomotive type VI inadequate supply of oil; added another lubricating oil pump.	No lubrication difficulties to date.	None.	None.
locomotive type IV no trouble except leaks; on type VI broke lubricating pump shaft.	No trouble with pump and no renewals.	No trouble with fuel or lubricating oil pumps; water pump has to be repacked every month.	No trouble; no renewal.
data available; no replacements.	No record. Not removed to date.	Have had no wear.	None to date.
filters.	Lubricating oil filter has brass strainers; no renewals.	Fine wire mesh.	Fine mesh screens; no renewals to date.
for adjustments and defects; monthly — a thorough inspection and packing of bearings, cleavages, etc.	On Monday of each week.	Every week on Sundays.	Every week.
	No trouble.	None.	No.
	No overheating of motors.	None.	No.

Number of question as listed in the questionnaire.	QUESTIONS.	Answers.	
		Reading.	Delaware, Lackawanna & Western.
204	Do the storage batteries require additional recharging, and how is this being done?	Not in ordinary operation.	No additional recharging necessary in service.
211	Have any difficulties been experienced with the air compressor, starting outfit, radiators, heaters, sanders, etc.?	Yes.	No difficulty experienced.
212	How often are the apparatus enumerated in the preceding item inspected?	Every 3 months.	Inspected every two weeks.
221	State in which respect mechanical parts of internal combustion locomotives are inspected and repaired differently from mechanical parts of other locomotives.	No difference.	Relatively the same.
222	Is the wear of mechanical parts different from that of ordinary locomotives? If so give comparative figures.	No.	...

the railroad should not be used in connection with information on expenses.

Column 2 gives the number of hours the locomotives had been working on each particular road during a certain period of time. Roads D and L gave statistical data for one year (1928); road A for two years (1927-1928); other roads for the whole time since placing the locomotives in service. For steam locomotives the roads gave statistical figures for a year preceding, or during, the service of the oil-electric locomotives, which were assigned to do the same kind of

switching work. Practically all railroads stated the number of hours of actual work; only one road (L) gave the number of miles instead of hours, and another also stated the number of cars handled in addition to the number of hours. The information regarding the number of cars has been omitted from the table, as it had no comparative value. As to road L, the number of hours was estimated for the table on the basis of six miles per hour, as prescribed by the Interstate Commerce Commission.

Column 3 shows the amount of engine

## Railroads.

<i>New York Central.</i>	<i>Illinois Central.</i>	<i>Hoboken Manufacturers'.</i>	<i>Donner Steel Co.</i>
	Batteries do not require recharging regularly but on occasion it is done from a house line at motor house inspection shed.	No.	No.
difficulties on locomotives types IV and VII. type VI burned out old coil on radiator power motor. Trouble with sanders when first used in service.	None to date.	None.	No.
reply to questions 154 and 201.	Inspection is made before leaving terminal to see that apparatus are operating properly. Afterwards they are inspected weekly and monthly.	Weekly on Sundays.	Each week.
on locomotive type IV. or types VI and VII not sufficient experience.	Inspection once a week. Steam switchers are inspected once a day or every two shifts of 8 hours each.	About the same.	The repairs require a better class of mechanic.
...	Have no figures and can make no comparison as no repairs have been made.	No.	The wear is much slower.

crew wages for the number of locomotives and the period of time included in column 2. The number of men in the crew on roads A, C, D, G and K is one; on other roads there are two men in the crew. This accounts for the difference in the cost of crew per hour, which can be obtained by dividing figures of column 3 by corresponding figures of column 2; they are given in table VI. For the above five roads with one-man crews they are respectively in dollars per hour: 1.079; 1.228; 0.983; 0.992; 0.944. For other roads with two-men crews, they

fluctuate from 1.543 to 1.654. The average for all roads is \$ 1.35. For steam locomotives they vary from 1.631 (road B) to 2.078 (road C), with an average of \$ 1.85. The wages of the conductor and trainmen are not included in the table.

Column 4 shows engine house expenses and the cost of supplies. For oil-electric locomotives this seems to be a very indefinite expense item. It fluctuates from nothing to 0.603 dollars per hour (see table VI — Road C), depending upon conditions of work, mainly upon conditions of storing locomotives between

Cost of operation of oil-electric switching locomotives (in U. S. dollar

1	2	3	4	5	6
Railroad (conventional designation).	Number of hours of work of locomotives.	Engine crew wages.	Engine house expenses and supplies.	Cost of fuel for main engine and auxiliaries.	Cost of lubrication oil and other lubricants.
<b>Oil-electric</b>					
A	6 924	7 473.94	3 591.05	1 164.03	245.86
B	14 762	22 782.75	8 172.57	3 195.22	1 080.89
C	9 123	11 201.87	5 502.22	1 938.36	547.00
D	5 185	5 095.48	420.80	1 112.19	457.68
E	16 871	27 413.71	(2)	4 075.20	1 324.19
G	3 225	3 198.83	203.32	761.40	169.76
K	9 140	8 624.29	(2)	1 256.30	448.70
L (7)	4 985 (3)	8 243.20(4)	679.43(5)	1 333.98	592.21
M (7)	2 560	4 231.52	157.62	858.86	137.71
<b>Steam</b>					
A	1 929	3 638.55	16.38	1 716.55	38.77
B	2 183	3 559.66	1 373.73	2 323.09	65.43
C	5 494	11 414.10	3 505.00	8 204.99	143.69
D	5 185	9 105.56	304.36	4 071.89	73.11
E	(6)	(6)	(6)	(6)	(6)
K	2 909	5 149.61	2 391.85	4 163.18	250.64
L	(6)	(6)	(6)	(6)	(6)

(1) Included in other items. — (2) Included in engine crew wages. — (3) Estimated on basis of locomotive locomotive mile. — (5) Estimated as difference between total and other items. — (6) Data not communicated by 300-H. P. locomotives (types I and III). — (8) Double fixed charges are included in the total cost of operation.

7	8	9	10	11	12	13
Cost of water and fuel for heating.	Cost of inspection and repairs (maintenance).	Total operating cost.	Cost of operation per hour of work.	Fixed charges on investment (interest and depreciation).	Fixed charges per hour of work.	Total cost of operation per hour of work, including fixed charges.

30.00	4 770.80	17 275.68	2.495	11 101.32	1.603	4 098
(4)	16 082.81	51 344.24	3.476	17 073.48	1.157	4.663
223.61	7 113.64	26 526.70	2.908	33 620.40	3.685	6.538
34.41	5 576.79	12 697.35	2.448	10 811.00	2 085	4.533
10.63	13 821.91	48 645.64	2.765	18 300.00	1.085	3.850
(1)	5 226.48	9 559.79	2.964	(6)	(6)	
198.48	8 692.94	19 220.71	2.103	15 145.83	1.656	3.760
61.20	6 674.07	17 584.09 (4)	3.527	9 820.80	1.970	5.497
(1)	1 332.34	6 718.05	2.624	(6)	(6)	

	2 101.76	7 512.01	3.894	129.65	0 067	3.961
87.34	2 075.36	9 484.61	4.345	1 717.00	0.787	5.918 (8)
347 54	5 475.61	29 090.93	5.295	5 280.00	0.961	6.256
77.78	3 762.80	17 395.50	3 355	4 275.00	0.825	4.180
(6)	(6)	(6)	3.370	(6)	0.538	3.908
192.00	2 676.20	14 823.48	5.096	525.00	0.181	5.276
(6)	(6)	(6)	5.140	4 500.00	0.903	6.043

miles assuming 6 miles an hour in switching service. — (4) Estimated on basis of locomotive miles and data per allroads. — (7) Data for these roads are for 600-H.-P. locomotives (type II). Data of roads A.-K. are for the reason that on road B each oil-electric locomotive replaced two steam locomotives doing the same work.

hours of service. Same is true for steam locomotives; on road A engine house expenses amount to only \$0.008, while on road K they are \$0.822 per hour.

Columns 5 of tables V and VI are very interesting; they show where the economy of the oil-engine locomotive lies. The cost of fuel oil and gasoline for auxiliaries fluctuates from 13.7 (road K) to 24.2 cents (road E) for 300-H.P. locomotives. For 600-H. P. locomotives this item goes up to 33.5 cents per hour. The reason for fluctuation is the same as given in reference to table III, mainly the variation in load factor of the oil-engine and also the difference in price of fuel oil. The latter fluctuated from 3.4 cents (road L) to 7.7 cents (road B) per U. S. gallon. On road B it dropped later to 4.3 cents. On other roads it was about 5 to 6 cents per U. S. gallon. For steam locomotives the cost of fuel was 78.5 cents (road D) to \$1.783 (road L) per hour, depending upon the size of the locomotive, with prices for coal ranging from \$3.81 to \$7.48 per ton of 2 000 lb.

The average cost of fuel for 300-H. P. oil-engine locomotives on roads A-K is 20.7 cents per hour, whereas the average corresponding figure for steam locomotives on those of A-K roads, for which data are available, is \$1.157 per hour, a saving of 95 cents per hour, or of 82.1 %. The corresponding figures for 600-H. P. locomotives on roads L and M, and for steam locomotives on road L (no data for road M have been communicated) are 29.1 cents and \$1.783, representing a saving of 83.7 %. The average figures for all roads are 21.6 cents for oil-engine locomotives, and \$1.295 for steam locomotives, with a saving of 83.4 %. Thus, the cost of fuel on oil-electric switching locomotives is less than one-sixth of that on steam locomotives doing the same work,

resulting in a saving of \$1.08 per hour in favor of the oil-engine locomotive.

Column 6 shows that the cost of lubrication fluctuates between 4.9 and 11.9 cents per hour, compared with 1.4 and 8.6 cents per hour for steam locomotives. The averages are 6.9 cents and 3.0 cents per hour for oil-engine and steam locomotives respectively, making a difference of 3.9 cents per hour in favor of the steam locomotive, and reducing by that amount the saving in fuel cost on the oil-engine locomotive.

The cost of water and fuel for heating, represented by columns 7, is negligible.

Column 8 shows a rather wide variation in cost of maintenance of oil-electric locomotives from \$0.52 to \$1.621 per hour, with an average of \$0.952. Maintenance of steam locomotives is more uniform, fluctuating between \$0.726 and 1.09, with an average of \$0.914, although the age of the steam locomotives under consideration varied from 10 to 63 years. Thus the cost of maintenance of the oil-electric locomotives is practically the same as that of the steam locomotives.

Column 9 of table V gives the total operating cost for each road. It is a sum total of columns 3 to 8. Column 10 shows the total cost of operation per one hour of work, with a variation for different roads between \$2.103 (road K) to \$3.527 (road L), and an average of \$2.852 (table VI). For steam locomotives the fluctuation is from \$3.370 (road E) to \$5.295 (road C), and the average is \$4.581, or \$1.729 more than the average net operating cost of the oil-electric locomotives. The fixed charges on investment (interest and depreciation) have not been taken, so far, into consideration.

The corresponding average figures for only 300-H. P. locomotives on roads A-K are \$2.809 and \$4.424 with a difference

of \$1.615 in favor of the oil-electric locomotive.

The most interesting columns are 11 to 13, as they show how the saving of the oil-engine locomotive is partly offset by the higher fixed charges on investment. Column 11 of table V gives the total figures of interest and depreciation, as estimated by the respective railroads, both for oil-engine and steam locomotives. Column 12 represents the same figures referred to one locomotive-hour, and column 13 is the sum total of the columns 10 and 12 giving the total cost of operation, including fixed charges. It can be seen that interest and depreciation as estimated by the railroads vary in wide limits for oil-electric locomotives from \$1.085 to \$3.685 per hour, depending partly upon the utilization of locomotives, namely, upon the number of hours of work per year, but mostly upon the variation in the rate of interest and depreciation considered by the railroad as a fair basis for calculation. For steam locomotives the variation is still larger — from 6.7 to 96.1 cents per hour, depending also, in addition to the above-mentioned two causes, upon the price of the steam locomotive built some twenty or thirty years ago. The average of fixed charges per hour of work is about one dollar higher for the oil-electric locomotive than for the steam locomotive, reducing the average economy obtained from the operation of the former from \$1.729 to about 80 cents per hour as compared with the latter.

A closer analysis of the figures for each road separately would be of value for the proper understanding of this important phase of the exploitation of oil-electric locomotive.

Road A assumes a six per cent rate for interest on the investment and a three per cent rate for depreciation. These charges

for the reported period of time amount to \$11 101.32, or \$1.603 per hour for the oil-electric locomotive, and to only \$129.65, or 6.7 cents per hour for the steam locomotive. The latter, which is the one actually replaced by the oil-electric locomotive, was an old locomotive built in 1865 and the cost of the locomotive was assumed by the railroad to be \$2 881.05. The comparison, therefore, is not in favor of the oil-electric locomotive, for which the railroad paid several years ago about 61 000 dollars, and the result is that an economy of \$1.399 in the cost of operation is turned into a net loss of 13.7 cents per hour.

Road B has a similar scale of rates — six per cent for interest and two and one-half per cent for depreciation — but the steam locomotives replaced by the oil-electrics are of more recent origin, and their value is placed at \$20 000. Besides, the oil-electrics are being utilized to the extent of 16 hours a day and their fixed charges amount, therefore, to only \$1.157 per hour. On the other hand, the steam locomotives could not be utilized more than 12 hours a day, and their fixed charges, in spite of the lower cost of the locomotives, went up to 78.7 cents per hour. Moreover, in view of the greater availability of the oil-electric locomotive, each of them replaced two steam engines. As a result, the total operating cost per hour of work of the oil-electric locomotives, including fixed charges, amounted to  $\$3.467 + 1.157 = \$4.663$ , and for the steam locomotives to  $\$4.345 + 0.787 + 0.787 = \$5.918$ , representing a net saving of \$1.56 in favor of the oil-electric for each hour of work.

Road C assumed a higher rate of depreciation, namely, five per cent, calculating interest at the usual rate of six per cent. At the same time the utilisation of

## Cost of operation, per one locomotive-hour, of oil-electric switching locomotives

1	2	3	4	5
Railroad (conventional designation)	Per one locomotive-hour			
	Number of locomotive-hours	Engine crew wages	Engine house expenses and supplies	Cost of fuel for main engine and auxiliaries
<b>Oil electric</b>				
A	6 924	1.079	0.519	0.168
B	14 762	1.543	0.553	0.216
C	9 123	1.228	0.603	0.212
D	5 185	0.963	0.081	0.215
E	16 871	1.625	(2)	0.242
G	3 225	0.992	0.063	0.236
K	9 140	0.944	(2)	0.137
L (7)	4 985 (3)	1.654	0.136	0.268
M (7)	2 560	1.653	0.061	0.335
Average of totals	...	1.350	0.257	0.216
<b>Steam</b>				
A	1.929	1.886	0.008	0.890
B	2.183	1.631	0.629	1.064
C	5.494	2.078	0.638	1.493
D	5.185	1.756	0.059	0.785
E	(6)	(6)	(6)	(6)
K	2.909	1.770	0.822	1.431
L	4.985 (5)	1.824 (4)	0.548 (4)	1.783 (4)
Average of totals	...	1.850	0.455	1.295

(1) Included in other items. — (2) Included in engine crew wages. — (3) Estimated on basis of locomotive-hours. — (4) For calculation of averages, the number of locomotive-hours is assumed to be equal to that of the steam locomotives. — (5) Data of roads A-K are for 300-H. P. locomotives (types I and II). Data of road L are for 600-H. P. locomotives (type II). Data of road M are for 600-H. P. locomotives (type I). — (6) Not included. — (7) Not included. — (8) Not included. — (9) Not included.

U. S. dollars) in comparison with steam locomotives doing the same work.

6	7	8	10	12	13
Work of locomotive.					
Cost of lubricating and other lubricants.	Cost of water and fuel for heating.	Cost of inspection and repairs (maintenance).	Total cost of operation.	Fixed charges (interest and depreciation).	Total cost of operation including fixed charges.
Locomotives.					
0.036	0.004	0.689	2.495	1.603	4.098
0.073	(1)	1.089	3.476	1.157	4.663
0.060	0.024	0.780	2.908	2.685	6.538
0.088	0.007	1.076	2.448	2.085	4.533
0.078	0.001	0.819	2.765	1.085	3.850
0.053	(1)	1.621	2.964	(6)	...
0.049	0.022	0.951	2.103	1.656	3.760
0.119	0.012	1.339	3.527	1.970	5.497
0.054	(1)	0.520	2.624	(6)	..
0.069	0.008	0.952	2.852	1.727	4.579
Locomotives.					
0.020	...	1.090	3.894	0.067	3.961
0.030	0.040	0.951	4.345	0.787	5.918 (8)
0.026	0.068	0.997	5.295	0.961	6.256
0.014	0.015	0.726	3.355	0.825	4.180
(6)	(6)	(6)	3.370 (9)	0.538 (9)	3.908 (9)
0.086	0.066	0.920	5.096	0.181	5.276
0.024 (4)	0.029 (4)	0.932 (4)	5.140	0.903	6.043
0.030	0.037	0.914	4.581	0.724	5.382 (8)
assuming 6 miles an hour in switching service. — (4) Estimated on basis of data per locomotive-mile. of locomotives on the same road. — (6) Data not communicated by railroads. — (7) Data for these roads double fixed charges are included in the total cost of operation for road B for the reason that on this average below.					

the oil-electric locomotive was only about six hours a day. This resulted in very high fixed charges amounting to \$3.685 per hour, more than thrice that on road B. The steam engines with which the oil-electric locomotives are compared were built in 1898 and 1903 at the price of \$16 000 each. The corresponding fixed charges amount to only 96.1 cents per hour, which, while high for a steam engine, is much lower than those for the oil-electric locomotive and notwithstanding the enormous saving of the oil-electric locomotive in operating cost (about \$2.39 per hour), the total cost of operation of the latter is in this particular case 28 cents per hour more than that of the steam locomotive.

Roads D and E have the same rates for interest (6 %), and almost the same rates for depreciation (3 1/2 % and 3 %). The prices of the steam locomotives are about the same (\$25 000; \$20 000 and \$22 500), although the utilization of the locomotives is different — about 8 hours a day on road D and 16 hours on road E. The fixed charges per hour are, accordingly, on the two respective roads, \$2.085 and \$1.085 for the oil-electric locomotives, and 82.5 and 53.8 cents for the steam locomotives. However, on road D the total cost of exploitation of the oil-electric is more expensive by 35 cents per hour than that of the steam locomotive — this in view of the low utilization of the locomotives in this kind of work. On road E the total operation costs are almost identical for oil-electric and steam, probably because the cost of operation of the steam locomotive per hour (column 10) is very low. As the latter cost is not itemized on that road, a further analysis is not possible.

On road K the rate of depreciation is three per cent, the same as on the majority of other roads, but the rate of interest

is only four and one-half per cent instead of six. On the other hand, the price of the steam locomotives replaced by the oil-electrics is \$7 000 each, and the utilization of locomotives in this service is about nine hours a day. In view of this, the difference between fixed charges for oil-electric and steam locomotives is appreciable, namely, \$1.475, notwithstanding the low interest rate. However, the saving in the cost of operation by the oil-electric is so high (about three dollars per hour), that the net saving amounts to \$1.52 per hour.

On road L a 600-H. P. locomotive is utilized 16 hours a day, and although the cost of the steam locomotive built in 1918 has been estimated by the reporter, in accordance with the general dimensions given by the railroad, to be as high as \$50 000, the fixed charges for the oil-electric locomotive exceed those for the steam locomotive by more than one dollar per hour, reducing the economy in favor of the oil-electric to 55 cents.

No fixed charge estimate has been obtained from road M.

A further discussion of this subject is given at the end of the next chapter.

### G. — Summary.

The experience with oil-electric locomotives on American roads has already established certain facts which have been compiled and stated in the foregoing chapters. This experience also indicates certain trends in the design and operation of oil-engine locomotives which the author thinks may not be amiss to discuss in the light of the information received from the railroads.

*Diesel engine.* — All Diesel engines in use at present are of the high speed, light weight type, the speed varying between 500 and 800 r. p. m. The only exception

is the New York Central McIntosh and Seymour engine on locomotive type VII, which has a speed of 310 r. p. m., but it is doubtful that this practice will be continued, as the same McIntosh and Seymour Corporation is now building locomotive engines with 700-800 r. p. m.

The reason for raising the speed is obviously the desire to reduce the weight of the oil-engine and of the generator. It is too early to establish what weights should be considered most economical. With the exception of Beardmore engines, which weigh about 20 lb. per horse power, the weight of locomotive oil-engines in service is in the neighbourhood of 55 to 63 lb. per H. P. This is considered by some builders to be too high, and attempts are now being made to develop engines weighing about 40-45 lb. per H. P., or even below 40 lb. The high speed engines require certain refinements in design and construction, the use of more expensive alloys, such as aluminum, cast steel, etc., and as a consequence, they are not cheaper for the same power, in spite of their light weight. While not yet definitely proved by actual figures, the indications are that the maintenance of high speed engines is more expensive than that of the lower speed engines; this may also prove to be true for the rate of depreciation. In addition to that, it seems useless to go to extremes in lightening the engines in cases when weight is needed for adhesion. The weight of the moderate speed engine usually represents from 12 to 18 % of the total weight of the locomotive; thus, if the weight of the engine could be reduced by as much as 50 %, this would amount to only 6-9 % of the total weight of the locomotive, which may not be of importance in all cases. For switching and partly for freight service some extra weight may be desirable, and in other

cases it is very probable that the saving in cost of the mechanical parts of the locomotive due to the lighter engine would be offset by the higher price of the high speed oil-engine.

There is, therefore, an economical lower limit to the weight of the locomotive oil-engine. The Canadian National 2 660-H. P. locomotive with two Beardmore light weight engines is of great interest and importance, and when figures of total cost of operation of these locomotives, including fixed charges, will become available, they will undoubtedly be of the greatest value. At present the author's opinion, based on the available experience with switching locomotives, is that the most economical weight for these purposes lies somewhere between 40 and 50 lb. per horse power. It is also this feeling that for road service the weight should be between 30 and 40 lb., the lower figures applying to passenger service.

In conformity with the above, it is also the author's opinion that the speeds of the oil-engines will in the future probably vary between 500 and 800 r. p. m., the lower figures for engines of higher output.

As to the number and location of cylinders, the straight six-cylinder vertical type, and twelve-cylinder V-type, are in use, the former, though predominating. Eight-cylinder vertical engines are not used at all on locomotives, probably for the reason of their inferior running qualities with regard to balancing and critical speeds. The twelve-cylinder V-type has the advantage of resulting in a shorter engine with smaller cylinders which do not require piston cooling. The V-type has, therefore, some possibilities for large power, although the straight vertical type will always have the advantages of simplicity and better accessibility.

All oil-engines in use on American lo-

comotives are of the four-cycle type, probably for the reason that there has not yet been developed a satisfactory high speed two-cycle engine.

With the exception of the McIntosh and Seymour engines on locomotives types III and VII, all oil-engines in America are of the solid injection type, which seems to have already conquered the railroad field. It is very unlikely that air injection type engines will be built for locomotives in the United States, at least in the near future. The McIntosh and Seymour Company itself is developing at present solid injection high speed engines for locomotives.

Of great importance for the development of the locomotive oil-engine is the question of the clearness of the exhaust. The possibilities of the two-stroke cycle in competition with the four-stroke cycle, high speeds versus moderate speeds, solid injection as compared with air injection, will always depend on the operation of these types with respect to smokelessness. It may not be necessary to have an absolutely invisible exhaust, but an exhaust which would not be objectionable to city authorities is of great importance. For service on city tracks and in terminals within city limits, the question of smokelessness will be of great consequence.

The two-cycle properly supercharged engine may be superior with regard to smokelessness to a four-cycle engine. The experience with the Danish Burmeister and Wain engines seems to prove this. A well supercharged four-cycle engine may also give a reasonably clear exhaust. In this respect the new four-cycle 1 000-B. H. P. Krupp engine installed on the Baldwin locomotive and the 1 400-B. H. P. Krupp engine for the Boston and Maine Railroad, both with supercharging (see Appendix II), will be of great interest.

In the opinion of the reporter, the present trend in development of the locomotive oil-engine is to settle on the six-cylinder, vertical, reasonably high speed, solid injection, four-cycle engine, with further studies of the possibilities of the V-type arrangement, two-stroke cycle and supercharging, especially for larger power.

*Power transmission.* — All American oil-engine locomotives are of the electric transmission type. A locomotive with gear transmission and magnetically operated friction clutches will soon be tested on the Boston and Maine Railroad. It is very improbable that any transmission other than electric will be used for switching purposes, and this for the reason that in this kind of service, where sharp curves, especially within city limits, have to be negotiated, trucks to which power is more easily transmitted electrically are indispensable. For road service the use of locomotives with gear transmission or air transmission, following the example of the Esslingen locomotive now undergoing tests in Germany, or the Austro-Italian Cristiani locomotive, is possible, but not before a reliable type will be developed. The reporter's opinion is that it will be long before the electric transmission on oil-engine locomotives will be replaced by a transmission of another type, notwithstanding the fact that the electric equipment adds a great deal to the weight and cost of the locomotive.

The electric equipment in use on all locomotives in America is either of the General Electric or of the Westinghouse Company's design and make. The two types do not differ essentially from each other. The motors are of the standard direct-current series-wound traction type developed to a high degree of perfection for straight electric locomotives. The

generators have not been standardized, the difference between them depending mostly on the system of control and the method of driving the auxiliaries. The switches and contactors are of the type used in ordinary electric locomotives.

*Control.* — On locomotives with General Electric Company's equipment the electric control is of the automatic Lemp type, as described in Chapter B, whereas on locomotives built by the Westinghouse Company the control is provided with an electro-magnetic torque governor, also described above. There is not enough available information for a comparison of merits of the two systems; both proved to be very satisfactory in operation, and both will undoubtedly be used in the future.

As to auxiliaries, it is the General Electric Company's practice to drive them from the exciter, which is designed so as to keep the voltage practically constant within the whole operating speed range, whereas the Westinghouse Company's system is to drive the auxiliaries from the exciter at working speeds, switching the load of the auxiliaries automatically to the generator at idling speed. There may be some advantages in the latter system, and a further study of the two systems of driving auxiliaries will undoubtedly be made. Consideration is also being given in some quarters to driving all auxiliaries from an independent auxiliary oil-engine.

In connection with the control, the question of the variation in speed and of the idling speed of the oil-engine must be considered. It would be possible to run the oil-engines at constant speed and control the output of the engines by regulating the admission of oil, but this would not result in good fuel economy. It is preferable to change the power by

regulating both the admission and speed, varying the latter from normal to approximately one-half. Therefore, practically all American oil-engine locomotives are equipped with variable speed governors, the setting of which is actuated manually by a handle. On locomotives with rheostatic control, the same handle operates the electric controller drum.

The wide variation in speeds necessitates placing the idling speed sufficiently low, somewhere about one-half of the rated speed. Apart from the consideration of fuel economy, it is desirable to have the idling speed as low as possible in order to avoid unnecessary noise during short stops in stations.

On the other hand, it is difficult to keep a large range of speeds in an oil-engine free from critical speeds, and while it seems possible in some six-cylinder, four-cycle engines, to eliminate criticals entirely, in others, especially in light weight engines, it becomes necessary to skip certain speeds, leaving out the corresponding notches from the control handle and thus not permitting the setting of the governor at these speeds for continuous operation. They are passed through very quickly.

*Water cooling.* — The question of cooling the jacket water and lubricating oil from the oil engine does not offer any difficulties. The required size radiators for cooling can be easily placed on a locomotive, either on the roof in small locomotives, or in special compartments with side or front ducts connected with the atmosphere, on larger locomotives. Practically all locomotives are provided with motor driven fans for the circulation of cool air, and this arrangement neither absorbs much power, nor involves difficulties in design and operation.

*Mechanical parts.* — All locomotives, whether of the single unit, or double unit type, have double end control. It has not been proved that this is necessary, especially for switching service, but so far no single control locomotives have been built except several 250-H. P. narrow gauge locomotives which were delivered by the General Electric Company to the United Fruit Company's plantations in Panama (see Appendix II).

As to the cab, frames, trucks, air brakes, wheels, etc., they are of the usual electric locomotive type and design, and no disadvantages of this practice have been experienced so far.

*Operation.* — Neither the handling of locomotives nor the maintenance of them offers any difficulties. No special qualifications for the crews on oil-engine locomotives have been found necessary. The handling of locomotives in terminals has been very easily organized on roads and the maintenance is conveniently taken care of. This will undoubtedly be further improved, as the number of locomotives at each point grows.

A very important feature of operation is that sometimes, due to the simplicity of control, it is possible to use only one man in the crew. This results in a saving in crew wages of approximately 50 cents per hour as compared with steam locomotives. The most important item in operation is, of course, the saving in the cost of fuel, which prompted the development of the oil-engine locomotive. In switching service it amounts to about one dollar an hour as compared with steam locomotive operation, resulting from the higher efficiency of the oil-engine. In conformity with figures given in table III, it amounts to 10-17 %, or as an average about 14 %, which is about six times as

high as the efficiency of steam switching locomotives, including standby losses.

*Operating expenses.* — With the exception of the two items of crew wages and cost of fuel, all items are approximately the same for oil-electric and steam locomotives. According to tables V and VI, the average saving in crew wages and fuel amounts to \$1.73 per hour in favor of the oil-electric locomotive. This amount is partly offset by the higher fixed charges. Some roads estimate the fixed charges so high that the whole saving is totally wiped out; others find a substantial economy in the exploitation of oil-electric locomotives.

For the purpose of comparison it is desirable to establish a uniform way of figuring fixed charges. The average cost of operation of a 300-H. P. oil-electric switching locomotive has been found to give a difference of \$1,615 in favor of the oil-electric locomotive. Assuming on the basis of past experience that the cost of an oil-electric locomotive of this size is \$60 000 and that the price of a corresponding new steam locomotive is \$25 000, and taking further as a fair rate of fixed charges 6 % for interest and 4 % for depreciation, we obtain a difference of  $(60\,000 - 25\,000) \times 0.10 = \$3\,500$  per year. In order to offset this extra cost by the economy of the oil-electric, it is necessary to have the latter in operation at least

$$\frac{3\,500}{1.615} = 2\,167 \text{ hours a year}$$

or, 7.22 hours a day, figuring on 300 days a year. If an oil-electric locomotive is operated more than 7.22 hours a day, there is a net gain in its favor; if less — then the oil-electric locomotive involves a loss.

It is not unusual for an oil-electric lo-

comotive to be in service 16 hours a day and 300 days a year, a total of 4 800 hours a year. The amount which such a locomotive can earn can be estimated as follows :

*Oil-electric :*

Operating cost per hour . . .	\$ 2 809
Operating cost per year :	
$2,809 \times 4\,800 =$	13 483.20
Cost of locomotive — \$ 60 000.	
Fixed charges, 10 % on the investment . . . . .	6 000.00
Total cost of operation. . . .	\$ 19 483.20

*Steam locomotive :*

Operating cost per hour . . .	\$ 4 424
Operating cost per year :	
$4,424 \times 4\,800 =$	21 235.20
Cost of locomotive — \$ 25 000.	
Fixed charges, 10 % on the investment as per above. . .	2 500.00
Total cost of operation. . . .	\$ 23 735.20
Net gain per year . . . . .	\$ 4 252.00

This amount is further increased to \$ 6 722 a year if the oil-electric locomotive, working 16 hours a day, replaces two steam locomotives. The gains can be still greater if the locomotive works 24 hours a day, six days a week, as the case is on some railroads. The greater availability, meaning the possibility of continuous service on the part of the oil-electric locomotive, permits the above mentioned sixteen and twenty-four hours' utilization and the replacement of at least two steam locomotives by one oil-electric. This availability is of great importance and consequences.

On the other hand, there are things which may influence unfavorably the results of these and similar calculations; if the railroad has at its disposal old

steam locomotives, the values of which have been either completely written off, or the cost of which was originally very low, the fixed charges of the steam locomotives are practically nil, and the difference between interest on investment and depreciation of the oil-electric and the steam locomotive goes up accordingly. This explains the variety of final figures in column 13 of table VI.

## H. — Conclusions.

1. The oil-electric locomotive has established itself in America as a useful type of motive power for switching purposes on railroads and in industrial plants.

2. The use of the oil-electric locomotive has been confined so far to yards and tracks within city limits, and because of its comparative smokelessness, it has the tendency of replacing the steam locomotive in this kind of service.

3. The oil-electric locomotive also proved to be readily available for service, reliable, simple and economical in operation, the economy depending upon the degree of utilization.

4. In order to realize the economies possible under prevailing cost of fuel, material and labor, and the existing prices of locomotives in the United States, it appears that the oil-electric locomotive must be utilized to about 2 200 hours a year.

5. Future development of the use of the oil-electric locomotive depends upon the relation between the above mentioned costs and prices, and especially depends upon the possibility of reducing the first cost of the oil-electric locomotive.

6. The oil-electric road locomotive has not yet passed the first stages of experimentation..

### Gasoline-engine locomotives in America.

There are very few gasoline locomotives in America. In reply to letters sent out to fifty five railroads in North and South America, practically all but three stated that they have no gasoline locomotives. Some of them had gasoline rail cars, which do not come within the scope of this report. The Erie Railroad has three locomotives with mechanical transmission, built by the Baldwin Locomotive Works some fifteen years ago; the Chicago Great Western has one locomotive of a similar type, also built by the Baldwin Locomotive Works in 1925, and the Chicago, Burlington & Quincy has a gasoline-electric locomotive built by the Mack International Corporation in 1929. There are some gasoline locomotives also in industrial plants.

The locomotives with mechanical transmission are of the 0-4-0 and 0-6-0 types, with frames, wheels and side rods of the usual locomotive design. A jack shaft, journaled in the locomotive frame, parallel to the driving axles, is direct coupled to the wheels by means of cranks and rods. The jack shaft is driven by a gasoline engine, usually of the vertical, four-cycle, single-acting, carburetor type with magneto-ignition.

In the Chicago Great Western locomotive the engine has six cylinders of 5 3/4-inch bore and 6 3/4-inch stroke, developing 225 B. H. P. at a speed of 1550 r. p. m. At 1250 r. p. m. the output of the engine is 180 B. H. P., and at 1750 r. p. m. it is 245 B. H. P. It was built by the Sterling Engine Company and is known as their Dolphin type, model GR. T 6. The engine is started from a 32-volt storage battery through a small electric motor geared to the fly-wheel. The storage battery is automatically recharged from a generator driven by the engine.

A friction clutch is placed in the engine fly-wheel and the transmission is obtained through a longitudinal shaft with one bevel pinion and two bevel gears for forward and backward direction, and a set of spur gears for the different speeds. The bevel gears and some of the spur gears are set loose on their shafts. They are always in mesh and are engaged and disengaged by clutches.

Radiators of the honeycomb type for cooling the jacket water are placed in front of the engine. They have forced air cooling from a fan driven by the extension of the engine shaft.

The Chicago, Burlington & Quincy locomotive has two four-cylinder engines with 5-inch bore and 6-inch stroke, developing 85 B. H. P. at 1550 r. p. m. The two engines are placed crosswise, with an operating cab between them. Each engine drives a direct connected generator of 55 kw., and both engine and generator are mounted on a common sub-frame. The locomotive has two General Electric motors, type HM-840, geared to each of the driving axles.

The starting of the locomotive is obtained electrically from a 12-volt storage battery. The control is of the ordinary resistance type. Two control stations are provided, one on the right and the other on the left side of the cab, each station comprising an engine throttle, a straight air brake valve, and a sander. There is only one direct controller located at the center of the end of the cab, where it can be reached from either control station. A fin type radiator is placed on the roof with forced air cooling from an electrically-driven fan.

The general dimensions of the two described locomotives are given in table VII.

TABLE VII.

## General dimensions of gas-engine locomotives on American Railroads

Railroad . . . . .	(Chicago Great Western).	(Chicago, Burlington & Quincy.)
Service . . . . .	Switching.	Switching.
Gauge . . . . .	Standard, 4'8 1/2".	Standard, 4'8 1/2".
Builders . . . . .	Baldwin Loco. W.	Mack Internat. Corp.
Wheel arrangement . . . . .	0-6-0	0-4-0
Weight, total, lb. . . . .	59 000	60 000
Weight on drivers, lb. . . . .	59 000	60 000
Length, overall . . . . .	22'-7"	19'-1"
Total wheelbase . . . . .	8'-6"	7'-6"
Rigid wheelbase . . . . .	8'-6"	7'-5"
Diameter of wheels . . . . .	36"	36"
Gasoline engine per locomotive . . . . .	1	2
Type of engine, cycle . . . . .	4-stroke.	4-stroke.
Number of cylinders per engine . . . . .	II	4
Size of cylinders, inches . . . . .	5 3/4" x 6 3/4"	5" x 6"
Speed, rev. per minute . . . . .	1 550	1 550
Rating per engine, B. H. P. . . . .	225	85
System of transmission . . . . .	Mechanical.	Electric.
Number of speeds . . . . .	3 in each direction.	...
Number of generators per locomotive . . . . .	...	2
Rating of generator, kw. . . . .	...	55
Motors per locomotive . . . . .	...	2
Rating of motor, B. H. P. . . . .	...	95
Method of starting engine . . . . .	Electric.	Electric.
Location of cooling radiators . . . . .	In front.	On roof.
Tractive effort, lb. . . . .	9 000 in low gear. 5 500 in intermed. gear. 2 600 in high gear.	8 860 at 3 m. p. h. 5 760 at 6 m. p. h. 3 960 at 9 m. p. h.

As to the operation of the locomotives, the information obtained is very meagre. It is to the effect that only one man is required in the crew, and that this man (the engine driver) on one road is assigned to the locomotive more or less permanently, while on the other he is being changed occasionally. The qualifications of the driver are about the same as for a steam locomotive. The handling of the gasoline locomotive is found to be less complicated than that of the steam locomotive.

On the Chicago Great Western Railway the locomotive is operated on the Southern Division between Cedar Falls and Cedar Falls Junction in Iowa, a distance of seven miles, hauling about three loaded cars at a time at a speed of 15 miles per hour. On the Chicago, Burlington & Quincy the locomotive is doing switching work at Beatrice, Nebraska.

The inspection of the engine, of the auxiliaries and of other parts of the locomotive is being made on one road once a month, on the other every twenty-four hours. The Chicago, Burlington & Quincy did not have the locomotive in service long enough to be able to communicate any figures. On the Chicago

Great Western the wear was found to be :

In crank shaft and connecting rod bearings : 0.003" per year.

In journals and crank pins : 0.005" per 100 000 miles;

In pistons : 0.0035" per 100 000 miles;

In cylinders : 0.007" per 100 000 miles;

In piston ring : 0.0015" per year.

Piston rings are replaced every 60 000 to 70 000 miles.

Locomotive can run 60 000 miles before crank shaft bearings or rod bearings require adjustment by taking out shims.

Intake and exhaust valves are re-ground every 1 500 miles.

There is no information about the mileage of the locomotive per year.

Regarding expenses of operation, the Chicago Great Western Railroad gives the following figures for an 8-hour day of work :

Crew wages . . . .	\$ 9.46
Gasoline cost . . . .	3.46
Lubricating oil cost. .	0.27

No information is given as to the cost of inspection and repairs, or the first cost of the locomotive, to the amount of interest on investment and depreciation charges.

## APPENDIX II.

**Latest types of oil-engine locomotives in America.**

Since the completion of the report, information has been received about several locomotives which had been placed in service on American roads and in industrial plants, or are about to be placed in service. One locomotive has been doing switching work for some time in the Eddystone plant of the Baldwin Locomotive Works. Although no operation data on these locomotives are as yet available, the reporter thought that a brief description and references to several publications will not be out of place in an Appendix to the report.

*Metropolitan-Vickers locomotives for Argentine.*

The Buenos Ayres Great Southern Railway placed in operation a 375-H. P. oil-electric locomotive of the B-B type, weighing 136 500 lb. The engine, manufactured by William Beardmore & Company, of Glasgow, is of the same high speed type as that used in locomotive type V (see C. — Description of Locomotives) for the Long Island Railroad, differing from that only in the number of cylinders, which is eight instead of six. The rated speed is 700 r. p. m.; the idling speed is 350 r. p. m., both slightly different from the corresponding speeds of the Long Island locomotive. The weight of the engine is 10 070 lb. It is started electrically from a storage battery.

The engine is directly connected to a Metropolitan-Vickers compound-wound, direct-current, 750-volt generator, rated at 300 kw. at 700 r. p. m. The exciter is a 9-kw. direct-current machine which serves also as a generator for auxiliary duties. The four motors are of the standard Metropolitan-Vickers series

traction type. The electric transmission is of the Westinghouse system. The total weight of the electrical parts is 42 000 lb.

The cab is of the riveted all over box type, with four side doors, two on each side. The radiator is of the English Coventry Radiator Company; it consists of finned tubes and is placed on the roof of the cab. It has 24 sections arranged in series parallel, in groups of four for water cooling, and two sections in parallel for oil cooling. There are no air blowers in the cooling system, the air circulation depending only on the movement of the locomotive. The cooling arrangement weighs 2 800 lb.

The engine has a vacuum brake with a motor-driven exhaustor made by Reavell & Company, which has a displacement of 163 cubic feet per minute. The motor, which has a capacity of 4.5 to 6 B. H. P., is made by the Metropolitan-Vickers Company. The 90-volt electric storage battery for starting the engine consists of 70 nickel-iron cells of 200 ampere-hours capacity. The battery is charged from the exciter while the locomotive is in service. The battery supplies current for lighting and electric control.

Two vacuum whistles, one at each end, and two electric headlights, one at each end, are provided. There are no sanders on the locomotive, and no boiler for heating.

The engine has not yet (November, 1929) been placed in regular service; however, tests have been already made. A non-stop run of 775 miles was described in the *Railway Gazette* of 16 August 1929, on page 255. The fuel consumption per 1 kw.-hour at the traction motors amounted to 0.729 lb. Statistical operation data are not yet available.

A second locomotive differing from

TABLE VIII. — General dimensions of some industrial locomotives

Builders	Baldwin.	Krupp.
Operator	Baldwin.	Boston & Maine
Road gauge	4'8 1/2"	4'8 1/2"
Wheel arrangement	1B-B1	4-8-4
Total weight, lb.	275 000	323 400
Weight on drivers, lb.	180 000	200 000
Length overall	52'1 3/4"	...
Length of cab	...	52'0"
Width of cab	...	...
Height overall	...	...
Total wheelbase	38'4"	44'1"
Rigid wheelbase	12'8"	17'0"
Diameter of drivers, inches	40	...
Oil engines per locomotive	1	1
Type of engine	Knudsen.	Krupp.
Maker of engine	Baldwin.	Krupp.
Number of cylinders	12	6
Size of cylinders, inches	9 3/4 x 13 1/2	16.93 x 16.93
Rated speed, r. p. m.	450	440
Rating of engine, B. H. P.	1 000	1 300
Type of generator	750 volts	... (1)
Rating of generator, kw.	...	... (1)
Motors per locomotive	4	... (1)
Type of motors	West. 353 D3.	... (1)
Electric control	Ward-Leon.	... (1)
Method of starting	Air.	Air.
Capacity of storage battery, A.-H.	...	...
Location of radiators	In front.	...
Tractive effort, adhes., lb.	45 000	...
Tractive effort, hourly rating	...	...
Tractive effort, contin. rating	...	...

(1) Transmission of power is mechanical — See description, Appendix II.

(2) Westinghouse torque governor control — See description of locomotives type V and VIII.

the first in that the Beardmore engine is replaced by a Sulzer engine is on order, but no particulars about the locomotive have been communicated by the Railroad.

*Krupp locomotive for the Boston and Maine Railroad.*

This is a 4-8-4 1 300-H. P. locomotive with mechanical transmission. The lo-

## recently built oil-engine locomotives.

Metropolitan Vickers. Ayres Southern.	Westinghouse.			General Electr. Co. United Fruit Co.
	Westinghouse El. & Man. Co.	Americ. Roll. M.	Western Elect. Co.	
5'6"	4'8 1/2"	4'8 1/2"	4'8 1/2"	3'0"
B-B	B-B	B-B	B-B	B-B
136 000	110 000	140 000	120 000	72 000
136 000	110 000	140 000	120 000	72 000
...	30'2"	35'2"	30'2"	30'10"
34'0"	25'0"	25'0"	25'0"	22'0"
10'0 3/4"	10'7 1/4"	10'7"	10'7 1/4"	8'8"
...	13'6 1/4"	13'3"	13'6 1/4"	13'6"
27'0"	22'8"	25'8"	22'8"	19'0"
7'0"	6'8"	8'0"	6'8"	6'8"
...	33	38	33	33
1	1	1	1	1
Beardmore.	Beardmore.	Beardmore.	Beardmore.	Winton.
Beardmore.	Westinghouse.	Westinghouse.	Westinghouse.	Winton.
8	6	6	6	6
8 1/4 x 12	8 1/4 x 12	8 1/4 x 12	8 1/4 x 12	8 x 10
700	800	800	800	750
375	300	300	300	250
750 volts.	West. 477	West. 477B	West. 477B	250 volts.
300	210	210	210	160
4	4	4	4	4
Met. Vick.	West. 562 D6	West. 582 FE6	West. 562 E6	G. E., H. M. 829
...	T. C. (2)	T. C. (2)	T. C. (2)	Autom. Lamp.
...	E. B. (2)	E. B. (2)	E. B. (2)	E. B. (2)
200	204	204	204	...
On roof.	On roof.	On roof.	On roof.	...
...	27 750	35 000	30 000	...
...	17 800	30 800	19 300	...
...	8 800	20 000	9 800	...

Electrically from storage battery.

comotive weighs approximately 356 000 lb. The oil engine is of the four-cycle, single-acting, solid-injection, six-cylinder type. The size of the cylinders is 16.93 inches (430 mm.) bore x 16.93

inches (430 mm.) stroke. At 440 r. p. m. which is the rated speed of the engine, the power is 1 300 B. H. P. The maximum speed is 470 r. p. m. and the idling speed is 100 r. p. m. A three-stage com-

pressor for supercharging, brake and starting air is directly connected to the crank shaft.

The transmission is of the mechanical four-stage gear type and operates in conjunction with friction clutches actuated electro-magnetically. The design of the transmission is similar to that of the Krupp Diesel locomotive with gears and magnetic clutches built for Russia <sup>(1)</sup> differing, however from the latter in that instead of the main magnetic clutch a newly developed hydraulic clutch is used.

The gears are selected in such a way as to permit switching, as well as freight and passenger service. For fast freight or passenger service it is proposed to use only three stages with following speeds :

2nd stage — 8.7 to 16.5 miles per hour.

3rd stage — 16.5 to 31.0 miles per hour.

4th stage — 31.0 to 60.0 miles per hour.

For slow freight and switching service the first three stages are used with speeds :

1st stage — 0 to 8.7 miles per hour.

2nd stage — 8.7 to 16.5 miles per hour.

3rd stage — 16.5 to 31.0 miles per hour.

The control to the clutches is obtained electro-pneumatically from a control wheel with electrical acknowledging features like those used in railroad signal equipments. The brake air compressor incorporated in the engine has a capacity of 120 cubic feet displacement per minute. For heating purposes a water tube boiler with a maximum pressure of 125 lb. per square inch and working pressure of 90 lb. per square inch, fired with fuel oil, is provided.

The locomotive has not yet (January, 1930) been placed in service.

#### *Westinghouse industrial locomotives.*

The Westinghouse Electric & Manufacturing Company built several locomotives for industrial plants and railroads, using the same Beardmore-Westinghouse light type engines previously referred to. A 55-ton, 300-H. P. oil-electric locomotive is being used as a switching yard locomotive by the Westinghouse Electric & Manufacturing Company itself; a 60-ton, 300-H. P. locomotive has been built for the Western Electric Company, and a 70-ton, 300-H. P. locomotive with heavier motors has been placed in service in one of the American Rolling Mills' plants. All locomotives are of the B-B type and have the general characteristics and special features of the Beardmore-Westinghouse design <sup>(1)</sup>. Particulars are given in Table VIII. No operation data are available.

#### *Baldwin-Knudsen locomotive.*

This is a 1 000-H. P. oil-electric locomotive of the 1B-B1 type with a 12-cylinder inverted V-type engine of the Knudsen design, built by the Baldwin-Locomotive Works in 1926. The oil-engine is of the two-cycle, single-acting type with mechanical fuel injection, with two crank shafts, each shaft having six cranks and rotating with the same speed and in the same direction by means of two spur wheels and an intermediate pinion. Each pair of cylinders, located in one transverse plane, has a common combustion space, and their cranks are so placed in relation to each other that the pistons travel downward and upward practically simultaneously, a lag being deliberately permitted for the piston controlling the scavenging air inlet.

The rated speed of the crank shafts is 450 r. p. m., whereas the speed of the

<sup>(1)</sup> *Railway Mechanical Engineer*, May, 1927, p. 270.

<sup>(1)</sup> *Railway Age*, 6 April 1929, p. 787; *Electrical Journal*, July, 1929, p. 305.

pinion shaft on which the generator is set is 1 200 r. p. m. Particulars can be found in the description of the locomotive which appeared in the *Railway Age*, 10 October 1925, p. 645 (1).

The engine is doing switching work in the Eddystone Plant of the Baldwin Locomotives Works. No operation data are available.

*Baldwin-Krupp locomotive.*

Quite recently a B-B type oil-electric locomotive for railroad service has been

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(1) See also *Oil Engine Power*, September, 1925, p. 523.

completed by the Baldwin Locomotive Works. The locomotive is driven by a 1 000-H. P. Krupp engine with scavenging, similar in design to that used in the locomotive for the Boston & Maine Railroad. The electrical equipment is of the Westinghouse type.

*United Fruit locomotive.*

Several narrow gauge locomotives have been built recently by the General Electric Company for the United Fruit Company. The locomotives are doing work in banana farms on the North-western coast of the Republic of Panama. Particulars are given in Table VIII.

## QUESTIONNAIRE

### on SUBJECT V

of the Madrid (1930) Session of the International Railway Congress.  
**Locomotives of new types: in particular, turbine locomotives and  
 internal combustion motor locomotives.**

#### Internal combustion locomotives.

##### General.

1. Road gauge, ruling grade and sharpest curve in yard, or on division where locomotive is operating.
2. Type of locomotive (wheel arrangement and approximate weight — 60 tons, 100 tons, etc.).
3. Names of builders of locomotive (mechanical parts), main engine and transmission.
4. Kind of engine fuel (gasoline, distillate, oil).
5. System of transmission (electric, gears with clutches, etc.).
6. Number of locomotives of each type and their road numbers.
7. Date of placing in service of each locomotive separately.
8. Kind of service (switching, freight, passenger).
9. Principal dimensions — length of cab, total wheelbase, rigid wheelbase, weight in working order, weight empty.
15. Rated power of engine at a given speed (revolutions per minute).
16. Normal, maximum and idling speed of engine.
17. If engine runs on gasoline, or distillate, give type and size of carburetor, stating size, number of venturi nozzle, main jet, compensating jet and idling jet.
18. If engine runs on oil, give system of fuel injection (air injection, or mechanical injection).
19. System of starting — by compressed air, or from a storage battery. In the first case state minimum pressure required for positive starting; in the latter case, the amperage and nominal voltage.
20. Attach an outline drawing of the engine with detail drawings of cylinder head, piston, connecting rod, crank shaft, crank case, base, cam shaft, fuel pump, water circulating pump, lubricating oil pump, various drives for auxiliaries, crank shaft connection (flexible coupling), etc.; or refer to a published description of the engine either in a magazine, or in a builder's bulletin, instruction book, etc. Indicate all deviations from the description as published, also all changes made in details and accessories of the engine since it was delivered by the builder, such as circulating pumps, air compressors, etc., if any.

##### Design.

##### a) Main engine.

11. Type of engine (four-, or two-cycle).
12. Type of cylinder (single-, or double-acting).
13. Number of cylinders.
14. Cylinder bore and stroke.

21. Weight of oil engine assembled, ready for application.
22. Enumerate filters and strainers incorporated in the engine (intake air strainers, fuel oil filters, lubricating oil filters, etc.).
23. Number and type of exhaust mufflers (silencers).
55. Cooling surface of the tubes of one section and total (plates and fins not included).
56. Natural or forced air circulation. In the latter case give number of fans, name of maker, capacity of each fan in cubic feet per minute with head in inches of water and speed.

#### b) Transmission.

31. If electric transmission is used, give brief description of generator, exciter and motors, as stated in order specification, or refer to a publication.
32. Indicate system of electric control (G. E.-Lemp system, original Ward-Leonard system, modified Ward-Leonard system) or refer to a publication.
33. If transmission of another system is used, give a description with drawings, or refer to a publication.
34. Weight of transmission complete.
57. System of driving cooling fans — direct from the engine, or by electric motors. In the latter case, state number of motors, their power, speed and name of maker.
58. Can any of the cooling sections be cut out at will?
59. Is the cooling system equipped with thermostatic control for by-pass circulation?
60. Can the circulation of water be continued after the main engine has been stopped?
61. Weight of radiators, blowers and other parts of cooling system.

#### e) Auxiliaries and accessories.

- c) Mechanical parts.
41. Give a brief description of mechanical parts with principal dimensions and attach corresponding drawings, or refer to a publication.
42. Weight of mechanical parts (without cooling system and auxiliaries).
43. Type of couplers and draft gears.
62. Type, capacity, system of driving and name of maker of air brake compressor.
63. Type, size and name of maker of starting equipment (gasoline-air compressor outfit). Number of air bottles and their capacity. Means for replenishing stored air in bottles.
64. If starting is obtained from a storage battery, state number of cells, trade name, voltage and capacity in ampere-hours. Means for recharging the storage battery.
65. Give details of the lighting and control storage battery similar to those of the preceding item, if separate battery is used.
66. Trade name, size (capacity, number) and type of fuel oil filter in addition to that incorporated in the
- d) Cooling system.
51. Type of radiators (flat-tube-and-plate type, circular-tube-and-fin type, etc.).
52. Makers of radiators.
53. Location of radiators (on the roof, in the front, on the sides).
54. Number of sections connected in parallel both for water and oil.

- oil engine. Kind of material used for filtering.
67. Give information on the lubricating oil filter (or centrifugal oil separator) similar to that of preceding item.
  68. State number and capacity of tanks for fuel (oil, gasoline) lubricating oil, and water.
  69. Number and capacity of sandboxes and type of sanders used. Location of sand pipes in relation to driving wheels.
  70. Type, size (capacity, number) and name of maker of heating boiler. Kind of fuel.
  71. Enumerate other accessories (bell, lamps, etc.) of the locomotive.
  72. Weight of all auxiliaries and accessories.
  73. Total weight of locomotive (items  $21+34+42+61+72$ ).
  107. How many control handles has the driver to operate for running, and what are their functions? What other buttons or handles has he to operate and for what purposes?
  108. Is the control of the locomotive convenient? Is it less, or more, complicated than the operation of a steam locomotive — in the latter case, state in what way.
  109. Does the locomotive require special handling in terminals or roundhouses?
  110. Name of place where the locomotive is doing its work (name of yard, division, etc.). Attach plan of yard, or profile of division.
  111. Number of loaded cars pulled at a time on various grades in the yard, giving speeds, if the locomotive is doing switching work; or tonnage of trains, giving schedules, if locomotive is pulling trains.

### Performance.

#### a) Operation.

101. Number of men in locomotive crew.
102. Is the second man needed for the operation of the locomotive irrespective of the Interstate Commerce Commission regulations?
103. If more than two men are in the crew, state the functions of the other men (third, fourth, etc.).
104. Is special training, or instruction, required for the crew, and if so, how much time is needed for proper instruction?
105. Are the qualifications of the locomotive crew as high as those of a steam locomotive crew? Are they higher, or lower?
106. Are the crews permanently assigned to locomotives, or are they being changed, and if so, are they changed oftener, or less often, than on steam locomotives?
112. When and where is the locomotive refueled, sandboxes refilled, lubricating oil changed, water tanks filled, storage batteries recharged?
113. Crew wages — total for each month and per unit of work, also terminal and roundhouse men's wages and other charges (sand, bulbs, etc.) — total for each month and per unit of work.

#### b) Fuel performance.

121. Specification of fuel (oil, gasoline, distillate) with physical and chemical characteristics (gravity Beaumé, flash point, viscosity Saybolt, carbon residue, ash, foreign matter, heat value in B. T. U., etc.). also source of delivery.
122. Does fuel oil need to be heated, and if so, by what means is it accomplished?

123. Have any changes been made in the fuel line, carburetors, injection valves, nozzles, filters, etc., to suit the kind of fuel? If so, describe the changes, accompanying them with drawings or sketches.
124. Does the locomotive emit smoke during operation and under what circumstances (full load, half load, idling, high speed, etc.)? State color of smoke (gray, grayish-blue, blue) and intensity of smoke (slight haziness, hazy, black, heavy black).
125. Performance sheets of locomotives, giving for each month since placing them in service, number of kilowatt-hours, ton-miles, or number of cars handled, hours of work, load factor, amount of fuel consumed for the main engine — total and per unit of time or work, cost of fuel per gallon (state U. S. or Imperial), total and per unit of work.
126. If auxiliaries or starting devices are run from separate engines, state kind of fuel, amount, cost per unit, total and per unit of work.
127. Has any relation been observed between fuel consumption and state of piston and piston rings (excessive clearance)?
134. What is used for lubrication of generators, motors, auxiliaries, gears, axle bearings, etc.?
135. How soon does the carbonization and dilution of lubricating oil become noticeable? Is the carbon completely removed by filtering? Is dilution being remedied in any way?
136. Has the effect of the cooling system on engine lubrication been noticed, and is the cooling water temperature controlled for better lubrication? How is this being accomplished?
137. Have carbon deposits in crank case been found and are they being removed? How often?
138. Consumption of lubricating oil for main engine for each month — total and per unit of time or work, in lb. and also in dollars and cents.
139. Cost of other lubricating material for the locomotive (oil, grease, waste, etc.) for each month — total and per unit of time or work.
140. If a centrifugal separator for the cleaning of lubricating oil is used, state operating advantages and disadvantages of this device as compared with ordinary filter.

#### d) Cooling.

- c) Lubrication.
131. Specification of lubricating oil, giving physical and chemical characteristics and source of delivery.
132. Have any changes been made in the lubricating oil line, pumps, filters, etc.? If so, describe the changes, accompanying them with drawings or sketches.
133. Is any oil, or grease, used for lubrication of other parts of main engine in addition to the forced feed system?
141. Have any changes been made in the cooling system after the locomotive was delivered to the railroad? If changes have been made, send a description with drawings or sketches.
142. Consumption of water in gallons and cost for each month — total and per unit of time or work.
143. Has pitting of cylinder jackets, sleeves (liners) and cylinder heads by cooling water been observed? How is this being taken care of?

## e) Heating.

151. Is the heating system connected with the cooling system? When and how is the connection being established and broken?
152. Is the circulating water heated before starting in order to facilitate starting of the main engine?
153. Cost of water and fuel for heating for each month — total and per unit of time or work.

## Inspection and repairs.

## a) General.

154. Is the main engine of the locomotive periodically inspected independent of repairs, and how often?
155. Are the auxiliaries and other parts of the locomotive periodically inspected and how often?
156. Have there been any serious repairs or replacements of parts of engine generator, motors, and other locomotive parts which required laying off a locomotive for more than a week? Describe the nature of repairs.
157. Were the heavy repairs of the preceding item accidental, or were they regular results of the design and service of the locomotive?
158. Have the causes of the heavy repairs been eliminated and how?
159. What kind of repairs require laying off of a locomotive for more than a day?
160. What is the average number of hours per month a locomotive is out of service due to inspection and repairs?
161. What is the average number of hours of service per locomotive per month?
162. What is the balance of the total number of hours per month and those of items 160 and 161 due

to fueling, sanding, storing, Sundays, holidays? How many hours are due to each of these causes?

## b) Engine repairs.

171. Have you had cases of broken crank shafts, cylinders, cylinder liners, cylinder heads, pistons, connecting rods and other heavy parts? What were the causes of the breakages? Have they been removed?
172. Were the above parts replaced or repaired, and if repaired, how was it done?
173. How long was the locomotive out of service at each time?
174. Can all other repairs be classed as « running repairs »? If not, enumerate those which cannot.
175. How many miles (or how many hours) does a locomotive run before the crank shaft bearings or crank pin bearings require adjustment — taking out shims, replacement of shells? Indicate whether shells, lined with white metal, are of steel or bronze.
176. What is the average wear of bearings on time or mile basis?
177. What is the average wear of journals and pins?
178. What is the average wear of pistons?
179. What is the average wear of piston rings?
180. What is the average wear of cylinders or cylinder sleeves (liners)?
181. When and how often are piston rings replaced on account of wear? What percentage of piston rings break within a certain time (six months)? What is the average life of rings?
182. What is the average wear of wrist (gudgeon) pins, and their bearings?

183. Is wear in piston grooves noticeable, and how is this being taken care of?
  184. When are pistons replaced?
  185. Have any advantages been found in the split-skirt-constant-clearance pistons as regards maintenance of cylinders, pistons, piston rings and other parts?
  186. What difficulties have been experienced with valves in cylinder heads? How have they been remedied?
  187. How often must intake and exhaust valves be ground? When and how often are they replaced?
  188. Are valve cages ever replaced? If seats are direct in the cylinder heads, are replacement seats inserted?
  189. Do valves get stuck? What are the causes and remedies? Of what material are guides of valve stems made? Have special bronze guides for valve stems been tried?
  190. How often do valve springs break? What is the average life of a valve spring?
  191. What difficulties have been experienced with fuel valves and sprays? How often are they inspected? When and how often are they being replaced?
  192. Are rubber seal rings used at the bottom of the water jacket (when the cylinder liner is removable)? Do they give trouble? How is the trouble being remedied?
  193. Has any corrosion of steel parts in the crank case been observed? How is this being eliminated?
  194. Has any difficulty with lubrication been met with? How has it been cured?
  195. What is the experience with the fuel, lubricating oil and water circulating pumps? Which parts require renewal and how often?
  196. What is the wear of the fuel pump plungers? When and at what intervals are they being replaced?
  197. What material is used for the strainers in the fuel oil and lubricating oil filters? How often is this material renewed?
  198. Cost of inspection and repairs of main engine per each month — total and per unit of time or work.
- c) Electric equipment repairs.
201. At what intervals is the inspection of electric equipment (brushes and commutators of generators and motors, relays, storage batteries, etc.) made?
  202. Have difficulties with commutation been experienced, and how were they remedied?
  203. Have there been cases of overheating of motors, and what were the results?
  204. Do the storage batteries require additional recharging, and how is this being done?
  205. Cost of inspection and repairs of electric equipment for each month of service — total and average per unit of time or work.
- d) Repairs of auxiliaries (including cooling and heating equipments).
211. Have any difficulties been experienced with the air compressor, starting outfit, radiators, heaters, sanders, etc. ?
  212. How often are the apparatuses enumerated in the preceding item inspected ?
  213. Cost of inspection and repairs of all auxiliaries (including cooling and heating equipments) for each month of service — total and average per unit of time or work.

## c) Repairs of mechanical parts.

221. State in which respect are mechanical parts of internal combustion locomotives inspected and repaired differently from mechanical parts of other locomotives.
222. Is the wear of mechanical parts different from that of ordinary locomotives? If so give comparative figures.
223. Cost of inspection and repairs of mechanical parts for each month of service — total and average per unit of time or work.

## Operating expenses.

231. Crew wages, terminal and round-house men's wages and round-house charges per unit of time, or per unit work — average for each year and for total time of service (on the basis of item 113).
232. Average cost of fuel, lubricating oil, water and fuel for heating, for each year and for the total time of service, per unit of time, or per unit of work (on the basis of items 125, 126, 138, 139, 142, 153).
233. Average cost of inspection and repairs per unit of time, or per unit of work, for each year of service and for the total time of service (on the basis of items 198, 205, 213 and 223).

234. Amount of investment (cost of locomotives), interest on investment and depreciation charges — total and per unit of time, or per unit of work.

235. Total operating expenses on time or work basis (items 231 + 232 + 233 + 234).

## Comparison with steam locomotives.

241. Give general dimensions, type, weight and year of construction of steam locomotives doing identical work with internal combustion locomotives.

242. State how many locomotives of the above type have been actually replaced by one internal combustion locomotive.

243. Give actual performance sheets of steam locomotives for each month during the last year of their service, comparable with sheets supplied on item 125.

244. Average figures for the last year of actual performance of steam locomotives comparable with those on items 231, 232 and 233.

245. Amount of investment (cost of locomotives), interest on investment and depreciation charges — total and per unit time, or per unit of work. State year to which the cost of steam locomotives refer.

246. Total operating expenses on time or work basis (items 244 + 245).

# REPORT No. 3

(Germany)

ON THE QUESTION OF THE USE IN RAILWAY WORK OF MACHINES FOR  
SIMPLIFYING STATISTICAL AND ACCOUNTANCY WORK (SUBJECT XIV  
FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL  
RAILWAY CONGRESS ASSOCIATION) <sup>(1)</sup> <sup>(2)</sup>,

By Herr TECKLENBURG,

Reichsbahndirektor, Member of the Headquarters Administration of the Deutsche Reichsbahn  
Gesellschaft (German State Railway Company), Berlin,

and Herr Dr. GAIER,

Direktor, Central Office of the same Company, Berlin.

Figs. 1 to 22, pp. 960 to 996.

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<sup>(1)</sup> Reporter for section I : *Introduction* and *The card punching machines* is Herr Dr. Tecklenburg, Reichsbahndirektor. Reporter for section II : *Other office machines and mechanical auxiliaries* is Herr Gaier, Direktor.

<sup>(2)</sup> Translated from the German.

The mechanization of office work is a most important question for the railway administrations : an enormous volume of correspondence between their business offices has to be controlled, a huge quantity of accounting work and statistical research has to be carried out, partly for internal use, and partly for State and provincial Authorities as well as for international purposes, and a great office organization has in the course of time become necessary to the German Railways to deal with this business. It is therefore understandable that the Authorities should in the past have steadily striven to avail themselves of such contrivances as typewriters and calculating machines, *pari passu* with their introduction in business houses. For a long time general development in this direction made only comparatively small progress. It is only during the last ten years that a quicker pace has been set in this direction under the influence of rationalization. Science is now providing an abundance of office machinery and other apparatus and it is the business of organizers to select from that which is offered, the auxiliaries most suited to the requirements of the railway administrations. It is of paramount importance that the introduction of such machinery must render working more *economical* : having in view the first cost and the high cost of amortization, due to rapid obsolescence of such machines, work must be cheapened or simplified, or other advantages such as speeding up or improved work must be forthcoming to counteract the increased expenditure.

Of all the machines which have so far been introduced by the Deutsche Reichsbahn, *those which operate by means of perforated cards* are the most important.

Their introduction has brought about considerable change of opinion with regard to the value and the potentialities of statistics. In the following paper the employment of these machines will be discussed in detail and finally the machines and apparatus chiefly used by the Reichsbahn will be dealt with.

### I. — Card punching machine.

We believe that the constructional peculiarities of the card punching machine are known; we think that our task lies in explaining how the machines are employed by the Deutsche Reichsbahn and the point of view which caused their extensive use. The great advantages offered by these punching machines lie, not only in the possibility of extracting statistical results, more quickly, more accurately and with reduced labour cost, but, and this must be emphasized, because of the exhaustive investigations rendered possible by the system, a means is offered of obtaining a very much better insight into the progress of operations. Information which could only be obtained at such a cost of time and labour, if purely manual methods were used, as to make it economically not worth while, comes easily to hand through the medium of the perforated card system, and areas which otherwise remain in darkness are laid open to investigation.

Of course one must not overlook the fact that certain dangers may arise : The advantages of the system may tend to raise statistics to a position which goes beyond the actual necessities of the business. Before introducing new, or amplifying existing statistics, it must be decided beyond doubt that such necessity exists, and that the results to be obtained will be worth the cost entailed. To

come to such decisions on a question of this kind an accurate appreciation of the cost of the perforated card system is indispensable. The Reichsbahn therefore makes a practice of ascertaining accurately the working cost of the perforated card method for each investigation and the costs and results, from the commencement to the completion of each investigation, are recorded in a proper manner on a special official form. It follows that the results so obtained serve as confirmation of the usefulness of the various perforated card offices and the Administration obtains information on the probable cost of introducing machines into new branches of the service and can reach a decision after having made estimates of costs and profit.

A. — Application of the system to the production of uniform operation and economic statistics.

The advantages inherent to the perforated card system in the way of speeding up and of extending statistical enquiries, have helped the Reichsbahn to the decision to bring the dead statistic to life, so that — a reflected picture of the results of operation — it may prove of value to the undertaking. In pursuit of this idea, the Reichsbahn has placed a high value on the production of a comprehensive statement, especially in so far as this shall deal with the work peculiar to each department of the undertaking, as regards class and quantity.

In some departments the mass performance of the various services can, it is true, be compiled by simple entry, thus for example, in the cases of clearance totals under which come the totals of passengers carried, the totals of luggage and express goods, the total tons

cleared of goods packages, tranship goods and goods in wagon loads. This is not however possible for the greater proportion of operations, particularly in the important department of train working, which includes movement of trains and locomotives. In this direction an understanding of the results can only be obtained in sufficiently wide detail if the ascertainment is made by means of the perforated card system. The way in which this work is usually carried out on the Reichsbahn by means of the perforated card system will be explained later.

Train and guards working are collated from the *train service ticket* (appendix I) which every guard must make out for each trip.

The train service ticket (guard's report) records : the train and vehicle-axle-kilometers run, both for loaded and light axles; these are further subdivided for home and foreign vehicles, postal, dining and sleeping cars, and further, the gross and nett tonne-kilometres for the loaded vehicles. The totals are divided in accordance with line classifications, that is to say for main or branch lines and into still more detail as to whether the service is regular or special and in such latter cases the subdivision goes still further.

The information as regards locomotives and locomotive staff is collected in the same way. It is collated from the *locomotive service ticket* (appendix II) which every locomotive driver must make out for each turn worked by a locomotive. The duty is here divided into train working and such depot service as shunting, reserve duty, waiting in steam and so forth. Train working is also divided in accordance with line and train classification and depot service is also dealt

with in accordance with duty performed and according as it is for goods or passenger service.

These very varied entries do not cause the staff any special trouble or hardship. The basis for it is provided by the time-tables, service classifications and circulars, and such service material.

The principle on which investigation is carried through, is that all original entries are made on special forms, since the first attempts to use linked cards (twin cards) gave rise to certain difficulties; the transfer to perforated cards is carried out by the Divisional Offices in special perforated card departments in which all this work is centralized. And further, this intention is carried out to the utmost by submitting the individual results to the Central Office on summary cards, since this practice makes the work of assembling the management results into complete form very much simpler and quicker for the Reichsbahn. These working statistics (performance statistics) which, in addition to the spheres already mentioned, cover other departments, partly with, and partly without the intervention of the perforated card system, give a full and accurate picture of the activities of the undertaking.

Through them the Administration obtains not only the material required to complete the general statistics, but also the ground work to meet the special service requirements. In the matter of research into train working, the Reichsbahn sets great stress on obtaining not only an idea of the section results for the various Divisional Managements but also of how the work done is distributed between the different sections. This is made possible by the fact that the sections in each Divisional Management area are designated by numbers which are

quoted by the drivers and guards in their train reports of work on the various sections. If therefore the perforated cards are sorted by sections, a « section loading card » (appendix III) can be obtained which will give the amount of traffic over all sections of the whole Reichsbahn network.

Of the very greatest importance is the demand of the Management that the results of these output researches should be placed in their hands at the earliest possible moment. This concern is on that account the deciding factor for the whole organization of train working research : this is so organized that a complete statement of results shall be available for the Management and over the whole system, in the shortest possible time, that is to say, within a week following the expiry of the week covered by the investigation; in this way the results of the investigation stage supply a recital which follows on the heels of the actual occurrences and provides a mirror-like indication of the seasonal variations of traffic and offers an opportunity to prepare means to meet the prospective demands of traffic.

Of course these investigations provide at the same time much that is useful and necessary for other purposes. In this way the perforated card system furnishes the ground work for the calculation of fuel premiums which are based on the locomotive tonne-kilometres hauled, and in addition supply the basis for calculation of the allowances which are part of the pay of the locomotive staff.

The desire to make use of the possibilities inherent to the perforated card system for providing the maximum amount of information has further led to the working statistics being expanded into a comprehensive operation statistic which

is continually dealing with the whole undertaking, and which, in combination with a somewhat similar compilation produced by the accounting side, has developed into a far reaching working costs account. These working statistics which show the inner ramifications of the business and make clear the import of individual incidents in the general scheme of things, are designed to bring the inner workings of the undertaking under a continuous and close scrutiny and give considerable assistance to the general efforts towards rationalization which the Reichsbahn has been making for years.

At the same time the working costs account forms the basis for the solution of a railway problem which the Congress repeatedly brings up and which it discussed at its last session, namely the calculation of railway working costs.

The cost analyses, which have been carried out over a number of years by the Reichsbahn with a view to arriving at the different factors related to the working efficiency of the various departments, are based on the operating costs, and bridge the gap between the latter and the actual traffic performances by means of special ascertainties which make clear the extent to which the operating performances are affected and exploited for the purposes of traffic.

There exist for purposes of working cost calculation two big and separate fields for investigation.

The *first* group is that which is destined to provide the basis for the ascertainment of the costs of operation, which may be looked on as characteristic of the work in the different departments. A working cost account does not only aim at a division of working expenditure as between passenger and goods traffic, but beyond this, at a further subdivision of

the expenditure in accordance with the facts established by the performance investigations, which shall permit of the proper proportion of expenditure being shown against the unit of the quantitative output.

The true hypothesis for a working account so built up, that the quantitative output for every section is known, is almost completely attained by the general performance statistics and only a few extensions of these statistics have been found necessary, such as for example those connected with performance of train marshalling and shunting service, which are likewise established by the perforated card system.

The second hypothesis, that the economic aim of each individual operation shall be established, is also likewise accomplished by the medium of the perforated card system: that was indeed the consideration governing the whole field of performance research. On these grounds the train and locomotive service tickets were so arranged for the purposes of train working research, that they set out for each movement of trains or locomotives the nature of the work performed, the nature of the section, the class of work, the class of train and the possible special duties as well as the local duties. At the same time the economical employment of the whole travelling personnel of the locomotive and train working staff is ascertained in exhaustive detail through the medium of the duty sheets.

The economical employment of the whole of the stationary personnel is also recorded by means of the perforated card system.

The basis for these researches is the attendance sheet which has to be filled up by every office and on which the

total personnel of the office is recorded in accordance with the nature of his employment. With this end in view the staff is very widely subdivided into branches of service which are so arranged that the economic object of the man's employment is as far as possible shown clearly and beyond all doubt; should a man do work which comes under more than one classification, he will be allocated proportionately to the different service branches in accordance with special local decisions which are as a rule based on consideration of work and time. The transfer of the attendance sheet to perforated cards and the handling of these cards is centralized by the Reichsbahn Divisions.

The *second* research group, which is necessary for the calculation of working costs, is that which has for its object the recording of the traffic operations carried out for handling the different kinds of traffic.

A portion of these ascertainment are also made through the medium of the train service sheets: in columns 26 to 31 and 24 to 30 the kind of traffic in which wagons hauled were used is recorded, *i. e.* whether they were utilized for the carriage of express goods, fast goods, ordinary goods, tranship goods or service material.

A special investigation of great importance is that concerning the employment of the wagon stock as a whole for the different descriptions of traffic. This is obtained through the medium of the *goods wagon operating researches* (appendix IV), which the Reichsbahn carries out from time to time. One of the objects of these researches is to fix the proportions of time occupied in the various operations of handling traffic, especially the time required for work at dispatch-

ing and receiving stations and the time taken up in moving it in trains. Note is taken of the time required for loading express and ordinary goods wagons, as also the time occupied in loading express single package and ordinary single package goods in local, tranship and interchange wagons, subdivided into loading time, time for removal to despatching station, running time in trains, delays on the road, time for placing for unloading, and unloading time. Further, in regard to the return trip, the times for preparatory work and light running are clearly indicated; the division of transportation as between the different classes of train is also recorded.

In passenger service the efficient use of the available vehicle capacity is checked by counting passengers and this operation is also now made over to the perforated card system. Here the number of passenger-kilometres run in terms of the different classes, both of trains and vehicles, is compared with the number of seat-kilometres worked. This investigation is made periodically on three weekdays and one Sunday in each quarter.

By means of this research the cycle of facts necessary for the working cost ascertainment is completed. And if in the course of these enquires more accurate research in any direction is shown to be required, the information essential for carrying out the cost analysis become available.

#### B. — Use of the punched card system in particular cases.

Beside the application of the perforated card system to spheres which have been mentioned above, and which utilized to the full the great advantages inherent to the system for amplifying the statis-

tical collection in order to create properly laid out and uniform statistics regarding management, numerous opportunities occur for research in particular areas, which can be made much quicker and cheaper by the use of the perforated system and these facts have therefore commended themselves to the Deutsche Reichsbahn.

The system has thus been brought into use for the *settlement of wagon hire*. This is organized as regards essential details in the following way :

A perforated entry card is made out for every foreign wagon coming on to the railways through an interchange station and in the same way a card is made out for each foreign wagon on exit and these are sent to the wagon settlement office. Here the cards are sorted in accordance with ownership and wagon numbers and advices of exit and entry are made out for each foreign railway in arithmetical order of wagon numbers. After the wagon concerned has been looked up in the exit advice by number, the details of exit are subsequently filled up on the entry card and it is punched. The completed entry card now contains all the information which is wanted for calculating the amount of hire. For entry : wagon number, owning line, interchange station, and day of entry; for exit : day of exit, interchange station, days stay, hire free time and time to be paid for. The debit advice for each Administration is then made up from the above details on the tabulating machine.

This method of operation results in considerable savings : formerly 141 persons were necessary in the wagon hire settlement branch while now 90 suffice; if the capital cost of the machine is converted in work units it is equivalent to a

further 26 persons bringing the total up to 116 or a saving of 25 persons.

Further possibilities for the use of machines are offered in the Stores Department. Here among other things the settlement of the service coal traffic has been made over to the perforated card system. The basis of this settlement is the service coal freight consignment note which is sent from the despatching to the receiving station for certifying receipt and from there to the Accounting Office at Railway Headquarters. Here the contents of the consignment note are entered on a perforated card. This then contains the month and day of despatch, name of despatching station, contract number, additional charges, kind of coal, delivery price, receiving station, wagon number, kilometres, freight, weight despatched and received.

All the information therefore that is necessary for the settlement with the Reichsbahn Divisions and the suppliers, as well as that for the fixing of the service goods freight, is available and at the same time everything is set out that is required to compile the service coal and general statistics.

Debits for material procured from Headquarters (the Reichsbahn Head Office) are likewise dealt with by means of perforated cards.

This system may be used to great advantage in the prosecution of the isolated and special investigations which are occasionally necessary and which can be handled in a very thorough manner over a very wide area. This is the case with « Duration of service statistics » which are made out at intervals of about three years and give the conditions of service for the whole personnel, the nature of their employment, their rank, their

rest periods, and so on, clearly and in full detail.

The perforated card system is used, on somewhat different lines, in connection with accidents in working statistics: here the value of the perforated card record lies in the fact that the card which is made out for each accident that occurs in working and contains a wealth of detail which may be referred to when investigating the individual accident, is attached to a file and remains permanently available for future reference.

### C. — Further extension.

The area in which information is collected by means of perforated cards, on the Reichsbahn, is a very wide one. The number of cards used reaches the total of about 90 millions per annum, which, divided over 32 offices, are handled by a staff of about 675 persons, through the medium of 79 tabulating, 87 sorting and more than 1 300 punching machines.

The Reichsbahn, however, does not consider that the possibilities of the system are as yet exhausted. Apart from the fact that it is being tried in certain departments, such as the stock book-keeping in the Reichsbahn repairs shops, a trial is at the present moment being made on a large scale, as to the possibility of changing over to the use of the perforated card system for the accounting, control and statistics of goods traffic. If the trials are successful a much wider and most important working field will be laid open to the perforated card system.

## II. — Other office machinery and auxiliaries.

In order that it shall not fall into error in regard to the mass of office machinery at present being put on the

market, the Reichsbahn has set apart one office in the Reichsbahn Central Office in Berlin, for the purpose of testing new office machines as regards their usefulness and economical working.

The tests are made through the medium of work and time studies: the work studies arrange the change over to mechanical operation and select the most suitable method for carrying it out; the time studies arrive at the time and cost of personnel for both the old hand and the new machine systems.

The following are the kinds of office machine in use at the present time.

### 1. — Typewriting machines.

Typewriters are used in the most extensive way in the offices at Headquarters and in Divisions as well as in all large and medium sized outside offices.

Under the lead of the German Standardization Committee (Deutschen Normenausschuss) the greater proportion of the typewriters and their accessories have been standardized. This standardization covers the quality, the dimensions and in particular the position of the letters in the keyboard. The main advantage of this standardization is to be found in the fact that the typist can, to meet the exigencies of service, change from one make of machine to another without difficulty.

Electrically operated typewriters have the advantage that they can be operated at a much higher speed (30 % increased output) without tiring the typist and turn out a large number of copies; they are installed in places where heavy and continuous correspondence is dealt with and where skilled « touch » operators are available.

In order that the typewriters could be used for bookkeeping they have in the course of time been fitted with wide car-

riages, decimal tabulators and front feed device.

Such typewriters find restricted application in the large goods stations for making out carriage free and forward consignment notes. In order to work up one column as required in these forms, an eight-unit totalizer mechanism (counter) has lately been produced which can be fitted to any ordinary machine. The amounts printed by the typewriter are at the same time recorded in the calculating mechanism and totalled.

The typewriters which are arranged for bookkeeping lend themselves to the booking of freight notes (consignment notes) on receipt on the so called accounting cards which serve for settlement with the consignee; they are made out simultaneously with the advice to the consignee of the arrival of goods and are written in one operation.

In the course of these bookkeeping operations a large number of columns have to be made up so that a single figure printing unit will not suffice. Large goods sheds therefore make use of calculating typewriters with wide carriages, decimal tabulators and front feed device. For calculating, that is to say adding, a number of printing and calculating mechanisms (counters) are attached to the machine in front of the carriage. The number of sets of mechanism that can be attached depends on the length of the carriage and the number of places for which figures are required. For instance a machine with a carriage 60 cm. (2 feet) long can accommodate 27 counters consisting of 7 units each (spacing variable) or alternatively, 44 counters of 4 units each.

As operating an ordinary calculating typewriter is tiring, the Reichsbahn buys

almost exclusively electrically driven calculating typewriters, in which not only the type bar is electrically worked but also the calculating mechanism and the return of the long and heavy carriage. Electric operation increases out-put by at least 30 %.

Such electrically operated calculating typewriters lend themselves to the preparation of wages and salaries sheets for the workmen and officials. The machine writes the various kinds of payments due — time and contract work — etc., and the deductions such as tax, sick fund, health insurance, rent, etc. for each employee on one horizontal line; it balances the amount and totals up the individual columns of pay and deductions for all employees in the same group.

If there are so many columns to be totalled that the machine has not enough totalizers for the purpose, the pay sheet is divided into one pay or salary list and one deduction list.

At the same time that the pay sheet is typed, the pay ticket for the employee, setting out tax and other deductions, is manifolded.

Electrically operated bookkeeping machines are adapted for use in connection with the perforated card system by coupling them with a punching machine (fig. 1). The machine operates as follows: as soon as a figure key on the bookkeeping machine key board is pressed the corresponding mechanism in the punching machine is actuated and punches a hole in the card corresponding in position to the figure printed by the typewriter. These coupled punching and writing machines simplify the work of perforation and ensure agreement between typescript and perforation.

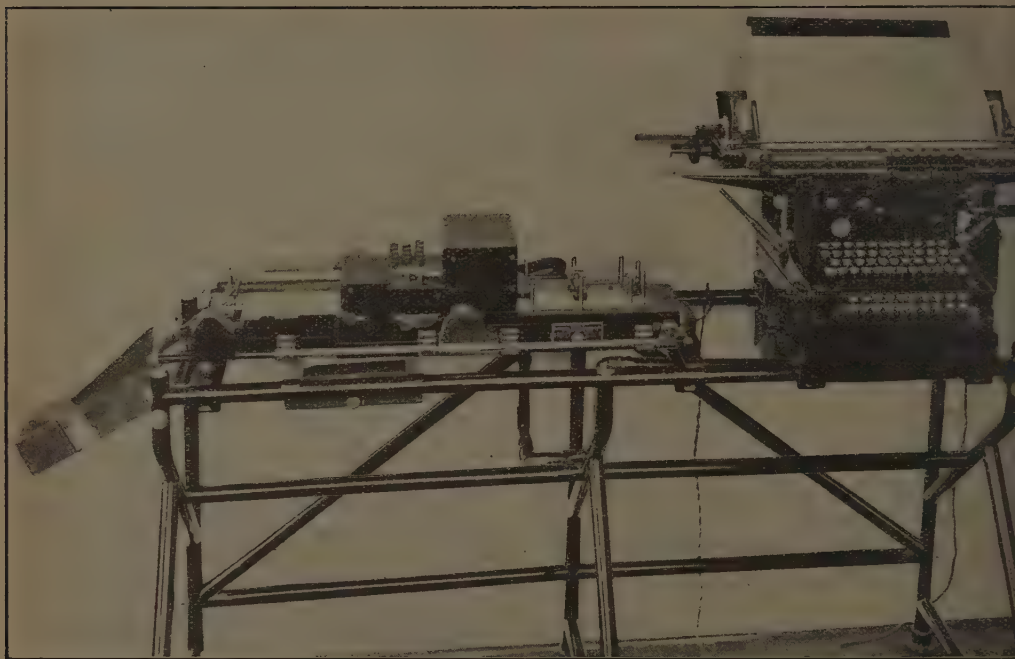


Fig. 1. — Electrically driven typewriting-calculating machine with exterior counting mechanism, coupled with card punching

## 2. — Duplicators.

The small offices of the Reichsbahn generally use flat duplicators having a clay or gelatine composition. Depots or offices of medium size use hand worked rotary duplicators. For the purpose of receiving the copy ordinary writing paper is generally used with a hectograph sheet prepared either by hand or on the typewriter. About 60 to 80 legible copies are obtained.

The larger offices use rotary duplicators electrically driven or worked by hand. Stencils are made of specially prepared paper or tissue. The number of

copies made from one stencil may be as high as 5 to 6 000.

In the Divisional Offices electrically driven duplicators are in use which print on paper from rolls or fan fold. These machines work, on the off-set system. Metal plates are used, impressed by means of types or press dies, as desired, or they can be inscribed by a typewriter, pen or stylus. The metal sheet can also be used for photo-mechanical reproduction of illustrations, script or drawings.

The output of such machines reaches 6 000 sheets Din A 3 ( $297 \times 426$  mm. =  $11 \frac{23}{32} \times 16 \frac{9}{16}$  inches) per hour.

The advantages of the above system of

duplication lie in the fact that the stencils can be produced very quickly. The personnel does not require to be specially trained to operate the duplicators.

Setting up is simple and quick.

### 3. Calculating machines.

#### a) Adding and subtracting machines.

Adding machines can be divided into two classes; those which have full keyboards and those with only 10 keys. The *full keyboard* machines have a row of keys for each column which include figures from 1 to 9. The noughts are written independently. The writing mechanism of most full keyboard machines can be split for tabulating.

The ten-key-machines have only ten keys for the figures 1 to 9 and 0, as also auxiliary keys for printing in two or three noughts.

As compared with the full keyboard, the small number of keys is more suitable for « touch operation ». The results of our time studies are generally in favour of the ten-key machine.

Hand operation for adding machines is being steadily replaced by electric drive; the advantage of this form of drive is specially evident on account of the suppression of the one time lever.

All adding machines are fitted with writing mechanism. The simple machines write the figures on a paper roll; all other machines are fitted with a carriage of the size usual for typewriters. In making out pay sheets, working in conjunction with addressing machine is advantageous (see section 7).

The Reichsbahn uses the following basic types:

*Simple adding machines with one totalizer (10 columns)*, for simple calcul-

ations such as those necessary in connection with goods working for adding up totals of all sorts, totalling weights, etc.

For totalling up the control strips of ticket printing machines which do not add (see fig. 8) simple ten-key machines which are specially secured against interference, are used. The printing mechanism and the paper rolls are cased in and the « not add » key is locked, while the paper roll can only be moved in the running direction. The totals worked out by these ticket control machines are absolutely correct when the totals of ticket issues *written* on the paper strip are compared with the results on the stamped strip of the ticket printing machine, and are found to agree.

*Adding and subtracting machines with one totalizer (10 columns):*

Must be divided as between machines capable of subtracting to 0 and the so called balancing machines with direct subtraction below 0. The first mentioned machines suffice for most requirements. For instance these machines are used by the Traffic Control to check the work of the issuing printing machines and to dispose of badly printed tickets and those sectioned for children, etc.

The balancing machines are used for simple bookkeeping operations.

*Balancing machines with more than one totalizer (10 and more columns).*

These machines are similar in their supplementary attachments to calculating typewriters but inferior in the matter of text writing.

The Reichsbahn Central Office uses a 10-key balancing machine for making up the salary lists; this machine has two totalizers and is electrically driven. The names of the employees are represented by numbers and the designations of the



Fig. 2. — Full-keyboard adding and subtracting machine (balancing machine) with 10 columns, 15 collector mechanisms, electric drive and split-up roller.

various deductions from salaries are also replaced by numbers.

In this pay sheet, 8 columns have to be filled in for each official and the emoluments of 160 employees can be worked out and entered up in an hour.

As the machine is only fitted with two totalizers, a large number of operations are required for the totalling of all the vertical columns.

Lately a 15-column full keyboard machine with 15 collector mechanisms has been under test (fig. 2.). This machine is capable of totaling up 15 vertical columns in addition to dealing with the

salary and deductions for each individual employee.

By coupling the adding and the punching machines (10-key machine, fig. 3) the separate work of punching is saved and the agreement between the figures typed and calculated on the 10-key machine and the punched card figures is assured.

The economy of the adding machines is dependent on the kind of writing and calculating work that has to be carried out. Saving of time is from 20 to 30 %. Employees are also released for more important work.

The adding machines which have been



Fig. 3. — Ten-key automatic adding and subtracting machine (balancing machine) with 2 counters, electric drive: coupled with card punching machine.

converted to accounting machines save appreciable time when run continuously. Conclusive experience has not however as yet been obtained.

**b) Machines for the four first rules of arithmetic.**

Machines with keyboard cost about twice as much as those with levers and shifting gear for the same output. The increased cost is however neutralized by

the much increased output if the machines are utilized to the full.

Working of the machines by hand is tiring, owing to the frequent repetition of operations required to multiply and divide. Electric drive adds about 500 Reichsmarks to the cost of the machine but increases the amount of work done.

We use the following from among the large number of systems:

*Simple calculating machines with car-*

rying over tens transmission in the rotary counting mechanism, with levers; shifters, and keyboard and hand drive for all simple calculating work in which multiplications predominate, such as accounting for freight, wages and material costs. Similar machines are used with electric drive, as well as a few with automatic multiplication and division for statistical calculations and for bridge designing, etc. (fig. 4).

Calculating departments (calculating rooms) and large offices are, where possible, supplied with special machines adapted to their peculiar requirements:

*Calculating machines with controlled carry-over in the totalizers* for calculations with more than two factors, used for the purchase of wood fuel (fig. 5).

*Calculating machines with several rotary totalizers*, for statistical and other calculations involving percentages.

*Calculating machines with divisible totalizers*, for calculations, in the course of which intermediate results have to be further dealt with, are *calculating machines with several totalizers*, for accumulating results and for the simultaneous carrying out of various kinds of calculations, such as checking and casting up the sales in ticket ledgers in the Control Office for passenger traffic and for working out freight proportions in the Goods Traffic Control Office (fig. 6).

The increase of output obtained by the use of calculating machines in replacement of mental work may be taken as being from 40 to 60 % in the case of multiplication and from 60 to 80 % in the case of division. The calculator working an electrically operated machine is specially freed from an appreciable amount of effort.

#### 4. — Cash registers.

a) Cash registers are widely used by the Reichsbahn for accounting the takings derived from the storage of hand baggage. Depending on the local arrangements of the cloak room counters, cash registers are used jointly for receipt and delivery or for receipt and issue separately.

These cash registers make it possible to do away with the signature of the receiving and issuing employee; they have totalizers for the number of pieces received, for recording the money takings and for the pieces of baggage issued.

Machines used in cloak rooms with a medium amount of traffic are for reasons of first cost not fitted for recording the pieces handled.

The provision of cash registers in the cloak rooms does away with the keeping of receipt books, speeds up the working, safeguards the receipts and makes control easier.

b) In goods traffic the cash registers are only of use for the despatch of carriage free consignments which are delivered with a three-part consignment note. The three-part consignment notes are primarily intended for the carriage free consignments of the mass consignors. Under this system all hand bookkeeping in despatching and receiving goods stations is done away with. The cash register prints in the name of sending station, day of delivery, weight and payment for carriage on the three consignment note sections and totals the free carriage amount.

There also cash registers which total not only the free carriage dues, but make up the totals for individual consignors but these totals must not exceed 45 at the most.

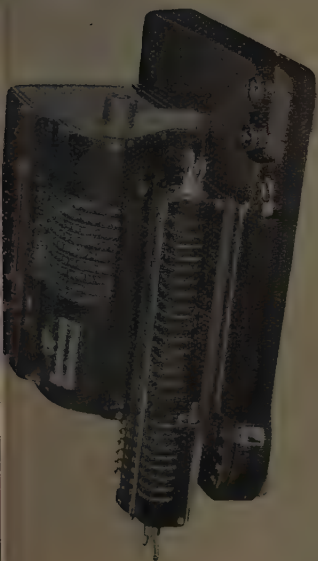


Fig. 4. — Calculating machine for the four first rules of arithmetic, electrically driven. — Levers and automatic division.



Fig. 5. — Calculating machine for the four first rules of arithmetic, hand driven. Levers, and provision for mechanical carrying over of result.

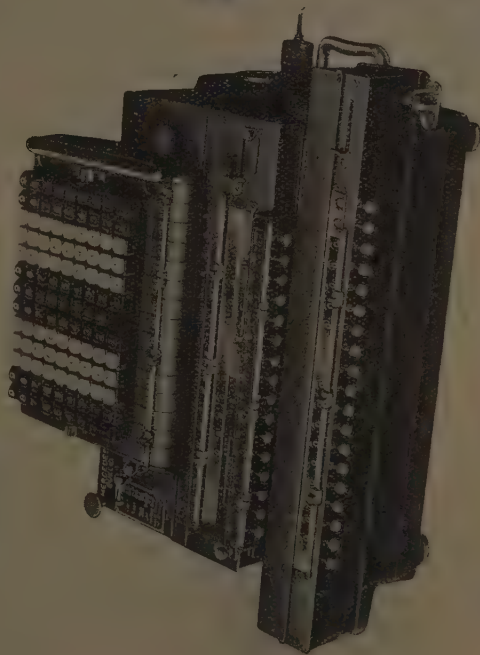


Fig. 6. — Calculating machine for the four first rules of arithmetic with electric drive, keyboard, automatic division. — Dealing with intermediate results and accumulating results.

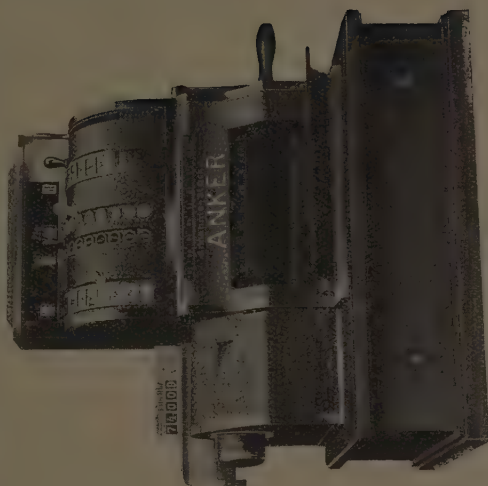


Fig. 7 — Cash register for acceptance and delivery of hand luggage.

The despatching station receives back in addition to the booking strip from the cash register one of the sections of the consignment note, the second section is kept at the receiving station and the third section goes to the consignee.

c) The cash register is of special importance in connection with express goods traffic. In 1928 the Reichsbahn handled more than 34 million express goods packages. The great partiality shown by consignors for this method of forwarding gave cause for some special encouragement.

The express goods receiving offices are usually crowded into a small space with the passengers luggage booking accommodation and the approaches are often very unsuitable. It was therefore necessary to speed up the taking over and despatch by properly organized methods and the installation of suitable auxiliary machinery to get over the want of space on the working floors and approaches.

The lay-out of a typical express goods forwarding installation is described in Appendix V, page 989.

### 5. — Ticket printing machines.

While issue of ready printed tickets from ticket cases is still practised today at booking offices handling a small traffic, a number of booking offices with busy traffic are fitted with *ticket printing machines*. These machines are only economical when the rates remain unaltered for lengthy periods.

The main advantage of the ticket printer lies in the control and accounting for the tickets. Ordering and storing of tickets are done away with. The booking clerk can calculate his sales in a minimum of time. Staff can be changed without loss of time, and without inter-

rupting the sale of tickets, because tickets have not to be made over. Checking is simplified and accounting made easier.

Beside this, appreciable savings accrue from the cessation of tickets printing and the keeping of registers at the ticket printing works. In booking offices working with *a* and *b* type printing machines, the number of tickets to be written by hand is considerably reduced, since the printing machines are fitted with so many printing plates, that tickets for many more stations can be printed than could formerly be stocked in the ticket cases.

a) The printing machines shown in figure 8 deliver two printed strips one of which is not accessible to the booking clerk and serves for purposes of control. The other strip emerges from the control casing and can be cut off by the booking clerk from time to time. This strip is used for purposes of calculation. This printed strip carries a running number, the cash value of the ticket printed, the class of ticket and a number from which the relative amount of traffic can be ascertained.

Since these printing machines operate without addition, it is necessary that the individual value of the tickets sold as shown on the control strip should be specially totalled up. This is carried out on a typing-adding machine specially protected against interference as described under « 3. — Adding machines ».

b) The printing machine shown in figure 9 delivers a control strip with running number, cash value of the tickets sold, vehicle class, train class and destination station. The price of all tickets is brought forward and added by means of a counting mechanism. This machine also at the same time provides



Fig. 8. — Ticket printing machine without totaliser. (Electric drive on the left, hand operation on the right).



Fig. 9. — Ticket printing machines with counting mechanism and electric drive.



Fig. 10. — Quick printers for passenger tickets (beside and above the window).

the basis for calculating the takings of the booking clerks.

The ticket statistics relating to numbers, class, kind of traffic, etc., are made more difficult by the printing machine. The only basis is the control strip and all the figures required must be abstracted from it.

c) The Stadtbahn and suburban traf-

fic round great cities demands, — particularly when the service is worked electrically — quick service to passengers at the ticket windows. As in this case the principal issues are for a few stations only, electrically-operated quick-printers (fig. 10) are the most suitable for such booking offices. The tickets are delivered ready for use on the issuing coun-

ter, by a short pressure on a key corresponding to the denomination of ticket required.

The quick printer delivers the calculations and statistics correctly and quickly; a separate counting mechanism is provided for each kind of ticket and this is inaccessible to the booking clerk. This counting mechanism shows at all times the total and the various kinds of ticket sold.

d) Automatic ticket machines are in use at all the larger passenger stations of the Deutsche Reichsbahn. One must differentiate between automatic machines which issue tickets from the pack or roll which have been previously printed and automatic printers. The advantages arising from the use of automatic ticket machines are to be seen in the rapid and comfortable supply to the passengers.

The automatic printers and the machines which issue from ready printed rolls provide the best facilities for accounting. Automatic machines which issue tickets from the pack still call for a check as to the stock.

#### 6. — Addressing machines.

Entries in headings and addresses on envelopes which are frequently repeated are mechanically printed on addressing machines. The address plates in use on the Reichsbahn carry in accordance with the size of the plate from 4 to 7 lines of print, 5.85 mm. (0.230 inch) apart, with from 30 to 36 letters of normal type, 2.6 mm. (0.102 inch) spacing. If pearl type is used more lines and letters can be got on a plate. The plates are made of tin. The letters are impressed on stamping machines. Alterations to the lettering do not make the plates useless; in point of fact about six changes can be

carried out. The impressions are struck off on single printers (fig. 12) worked by hand or foot or on printing machines with electric drive.

The cost of purchasing the plates and the necessary storage cupboards and the stamping of the plates is small. The addressing installation, especially when using the single printer provides an exceptionally advantageous opening for organization.

*Single printer installations* are used by preference (by the Reichsbahn Divisions, by head cashiers' offices, etc.) for the addressing of letter wrappers and for filling up headings. Such offices as are supplied with these machines can use them to advantage for various subsidiary purposes as for example the making out of postal delivery receipts, simple quitances and admission tickets for special occasions.

The application of single printer installations in the preliminary examination of consignment notes, is mentioned in Appendix II as being a specially advantageous example of their use.

*Printing machines* are used for the copying of names and other fixed entries (such as family state, membership numbers, class of contributions and important dates) in salary and wages lists.

The stamped plates used in making out the pay sheets are, thanks to a simple arrangement which permits of a part only of the plate being used for printing, available for printing pay bags, tax cards, contribution lists and other such work.

The Reichsbahn Repair Works use addressing machines very largely in combination with accounting machines (see Section 3) for making up wages sheets. Some Reichsbahn Divisions use similar installations for the completion of pay



Fig. 11. — Automatic ticket machine with electric drive.



Fig. 12. — Single hand printing machine (addressing machine).

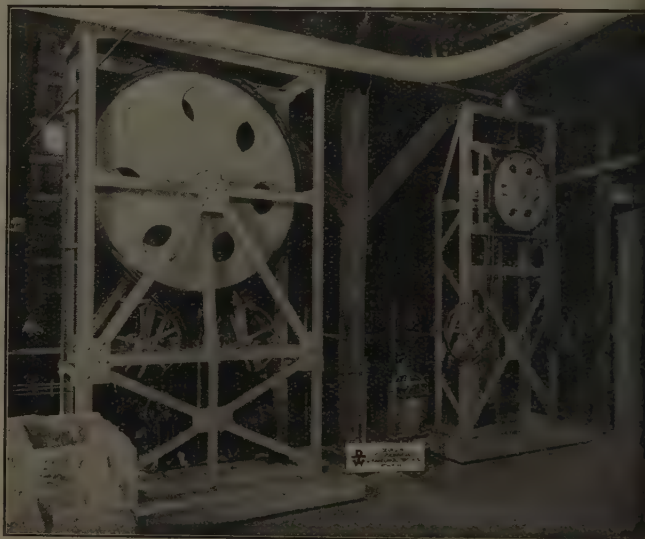


Fig. 13. — Driving gear of express post for documents.

sheets for the salaried staff pensioners, etc., for printing the names, numbers etc., of the payees.

Of late the plates for making up of pay sheets where the payments do not vary (salaries, rents) are stamped with all the amounts composing the payment as well as the individual amounts of the deductions. With the assistance of the covering arrangement all the entries for each individual payee can be printed in the lists line by line, by the use of one plate. It is thus possible to use a simple adding machine for reckoning up the lists instead of the expensive accounting machine.

The varied uses to which the address plate and addressing machine may be put may be gathered from the examples given above and these, combined with the low price of the machine, are leading the Reichsbahn to continued extension of their use.

## 7. — Other mechanical auxiliaries.

### a) Express post for documents.

Electrically operated lifts are as a rule installed in large administration buildings for transmission of documents vertically from floor to floor and these automatically serve the different floors.

An express document post has been installed in the Headquarters buildings of the Reichsbahn in Berlin to connect the document lifts in the old building with those in the new extension. It consists of a conveying rope running on rollers which can be operated in any direction, vertically, horizontally as well as on rising or falling inclines. The operating station for this conveyor is situated in the old building under the roof (fig. 13).

An electric motor runs the driving sheave (at left in the illustration). On one side (at the right in the illustration) is the tensioning sheave for taking up the slack in the rope. The boxes for holding documents are made of aluminium and have inside dimensions of  $40 \times 30 \times 10$  cm. ( $15 \frac{3}{4} \times 11 \frac{13}{16} \times 3 \frac{5}{16}$  inches); they can hold 5 kgr. (11 lb.) of papers.

They are attached to the rope at the despatching station and are carried automatically forward as soon as one of the carriers built in to the rope passes the station (fig. 14-left) and are taken on to the station for which the document boxes are destined. There the boxes are automatically disconnected and remain hanging in a frame till they are removed by a messenger. Three boxes can come into any station one after the other. As soon as three boxes have come in the station, it is closed and a bell continues to ring till at least one of the boxes has been taken out.

The economy arising from this express post is due to the saving in messengers and the speeding up of delivery.

### b) Mechanism for announcing visitors.

In order that as few guides as possible shall be required for announcing and accompanying the numerous callers who come to see the buyers and others, the following installation has been provided in the Headquarters building of the Reichsbahn.

In the doorkeeper's office on the ground floor, which is also used as a waiting room for callers, was placed a board which bears the number of each of the buyers (in the Reichsbahn Central Office each official has a number) in



Fig. 14. — A station of the express post, where the boxes containing documents are taken off or sent on.

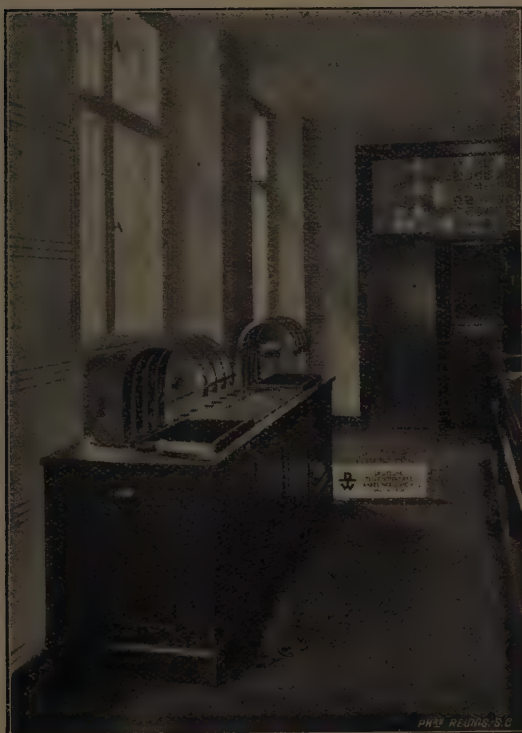


Fig. 15. — Installation for announcing visitors, with board showing whether official to be called on is present or not. (Tube post in the foreground.)

triplicate on red, green and yellow glass (fig. 15). If the red glass is lit up, the buyer is in his office but cannot see callers; if the green glass is lit, he is in and can be seen; if yellow, he is not in his room but somewhere in the building. If none of the three glasses are lit, the buyer is not in the building.

The lighting of the numbers is carried

out by the buyer pressing red, green or yellow indicators on his desk. When the green number is illuminated the doorkeeper sends up the caller's card by the tube post to the buyer concerned. The buyer notes on the card if he will see the caller, and returns the card to the doorkeeper and the caller is then free to go to the buyer without a guide.

## CONCLUSIONS.

1. The installation of office machines and other mechanical auxiliaries is justified if it results in more economic working.
2. Increased economy can be achieved *directly* by simplification and cheapening of the work or *indirectly* through the possibility of speeding up and improving the work to be done.
3. The introduction of the punched card system has been a specially important advance in statistical and calculating operations.
4. The advantages obtained from the punched card system lie in the possibilities for :
  - a) carrying out investigations more quickly, more accurately and more cheaply, and numerous opportunities of this nature are therefore offered to the Railway Management.
  - b) carrying investigation deeper and opening up areas to research which could not have been dealt with by purely manual means. As a result light is being shed in places hitherto inaccessible and as a consequence the solution of important problems of scientific railway management is rendered possible.

APPENDICES I to VI

### Train classifications 1-9

in which operations are carried out :

Week No. .... Date ...../...../..... 192.....

### Train class numbers.

- 1 = Express trains.  
2 = Fast trains.  
4 = Stopping trains.  
5 = Light stopping passenger trains, rail motor cars and rail motor car trains.  
6 = City, Circle and suburban trains.  
7 = Passenger trains carrying goods.  
8 = Express goods trains.

Station at which the ticket is given up :  .....	Checked :
	Name : .....  Rank : .....

[illegible]

Class numbers for extra passenger train services and other special train working.

1. Special trains run by the Management to strengthen timetable services without fare reduction also relief trains before and after booked trains.
2. Special trains run by the Management with reduced fares (week-end, sport meetings, the trains for Leipzig Fair and similar exceptional holiday traffic).
3. Special trains ordered by individuals and parties.
4. Empty trains of passenger vehicles, to time table.
5. Specials of passenger vehicles.
6. Locomotive trips with goods vans (booked).
7. Locomotive trips with goods vans (special).
8. Holiday specials.

## Train service ticket B

**Train classification 10 to 32 and 34 to 37.**

Reichsbahn district

in which operations are carried out :

Week No. .... Date ..... / ..... 192.....

[illegible]

## Train class numbers.

- 11 = Through fast goods trains.
- 12 = Short distance fast goods trains.
- 13 = Through goods trains.
- 14 = Short distance goods trains.
- 15 = Mixed trains.
- 16 = Light goods trains.
- 17 = Tranship trains.
- 21 = Covered empties.
- 22 = Open top empties.
- 23 = Empties.
- 30 = Work trains.
- 31 = Service trains.
- 32 = Trains of damaged wagons.
- 37 = Works trial trips.

## APPENDIX I-B.

Station at which the ticket is given up :  _____ _____ _____	Checked :  Name : _____ Rank : _____
--	---

[illegible]

- 4) Ordered trains for goods traffic.
- 5) Special trains for goods traffic.
- 8) Light engines with goods vans (booked timings).
- 9) Light engines with goods vans (special timings).

## Locomotive service ticket

No. ....

sent off under  
despatch numberDate  
d month)

Locomotive

Depot : .....

Reichsb. Division : .....

1			2			3			4			5			6			7			8			9			10			11			12			13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
Locomotive			Locomotive driver			Locomotive			river			river			river			river			river			river			river			river			river			river			river																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
Kind of traffic	Performance figure		Running weight in tons			Name	ber	Home station		Depot	Service roll	Groups		Order number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot	Number			Depot			

APPENDIX II.

[illegible]

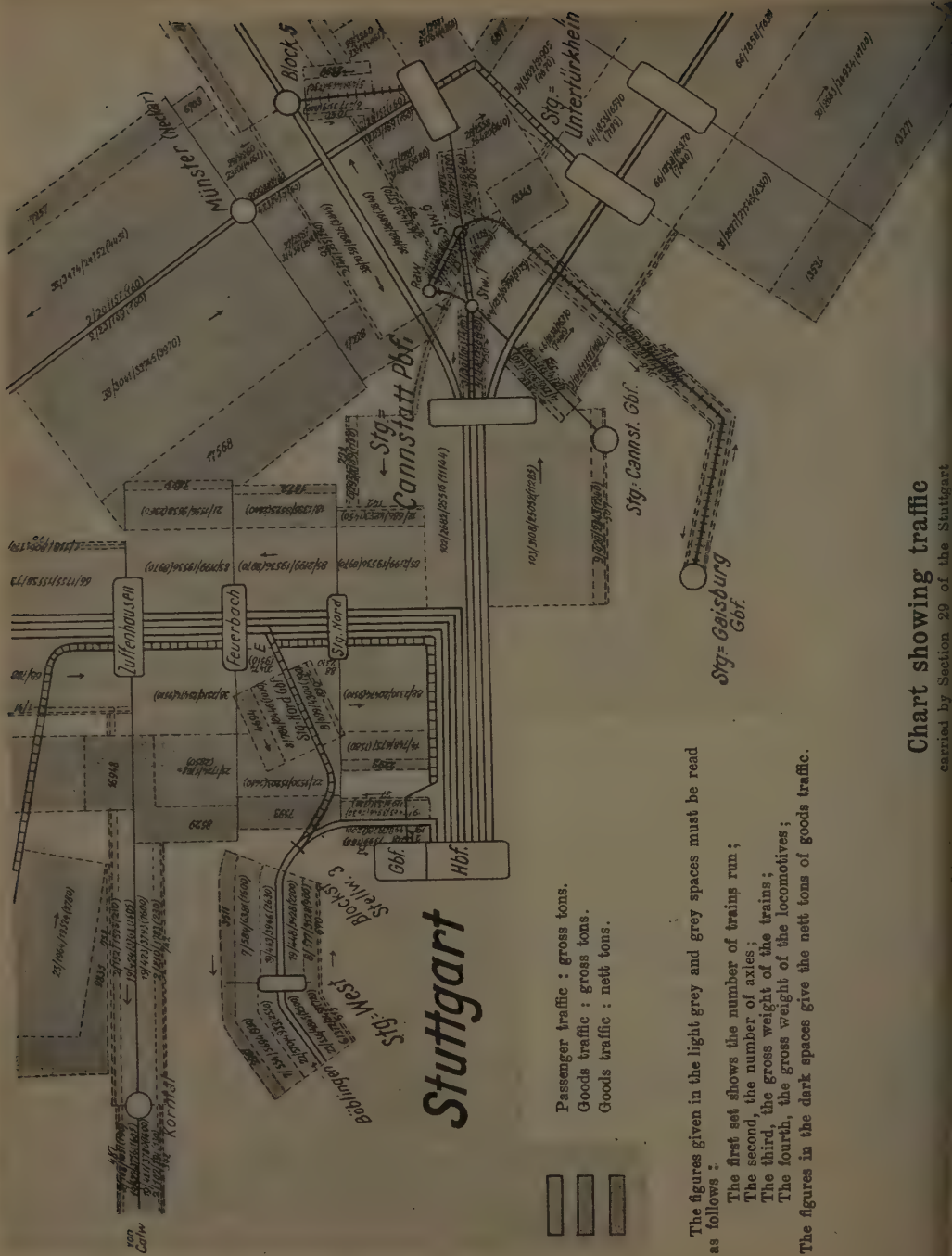


Chart showing traffic carried by Section 29 of the Stuttgart

## Remarks:

<sup>1)</sup> Wagon classification.  
 G = 1 R = 5  
 V = 2 S, SS = 6  
 K = 3 H = 7  
 0, 00 = 4 X = 8  
<sup>2)</sup> Loading places. = 1

Free loading places, private sidings, port lines, industrial lines or loading and unloading of private goods on free places. = 2  
 Goods sheds, express goods sheds, loading into trains. = 3  
 Railway loading places (Works, Stores, Yards, etc.) or loading or unloading service material on free places. = 4  
 Transfer of wagons from foreign lines or loading from narrow gauge lines. = 5

<sup>3)</sup> For a "tonnage control" always indicate "T".

<sup>4)</sup> Not to be filled in for wagons without special destination nor for privately owned wagons.

<sup>5)</sup> Methods of despatch:

Express goods wagon loading. = 1

Ordinary goods wagon loading. = 2

Special destination wagons for:

Express goods in packages. = 3

Ordinary goods in packages. = 4

Dangerous goods. = 5

Tranship wagons for:

Express goods in packages. = 6

Ordinary goods in packages. = 7

Dangerous goods. = 8

Wagons without special destination:

For express goods in packages. = 9

Ordinary goods in packages. = 10

Dangerous goods. = 11

Milk. = 12

<sup>6)</sup> Private goods. = 1

Service goods. = 2

Military goods. = 3

<sup>7)</sup> Kinds of goods:

Manures of all kinds. = 1

Hard coal, coke and briquettes. = 2

Lignite, coke and briquettes. = 3

Stone and broken stone. = 4

Other goods. = 5

To be filled in by despatching station:

# Movement

sheet for loaded wagons.

Owner's mark.

Wagon number.

Class of wagon (1)

Mü

51403

1

Klingenthal

Grauhof

from Despatching station.

to Destination station.

1			2		3		4		5		6							
Number of loading district.			of loading station.		Placed ready for loading.		Loading completed.		Excess over free time in hours (2).		Delays at despatching station on account of:							
											a	b	c	d	e	f	g	h
										Demerits missing	Customs	Weighting	Sunday rest	Repairs	Embargo	No room in train	Other causes	
										Punch with								
											1	2	3	4	5	6	7	8
2	3	4							5	6	7							
0	6	1	22	7	23	10			1	5			yes					

Owner	Wagon number	Class
		1
Mü	51403	1

To be filled in by train conductor :

29	30	31	32	33	34	35	36	37	38
		a	b	a	b	a	b	a	b
Station	Day	Time of		Duration of stops		Kilometres and running time in the train classification			
		Arrival		Departure		11 and 12	13	14	15
		Hr.	Min.	Hr.	Min.	km.	Running time Hrs. Min.	Running time Hrs. Min.	Running time Hrs. Min.
Klingenthal	out	24		12	18				
Falkenstein	in	"	15 36						
	out	"		19	38	4	02		
	in	"	21 17						
Herlasgrün	out	"		21	38		21		
Reichenbach i. V.	in	"	21 58						
ob. Bf.	out	25		1	30	3	32		
	in	"	4 20						82
Gaschwitz	out	"		22	17	17	57		
	in	26	0 21						19
L. Wahren	out	27		8	14	31	53		
	in	"	9 18						26
	out	"		9	50		32		
	in	"	12 46					59	2 56
Aschersleben	out	28		11	48	23	02		
	in	"	14 50					31	3 02
Halberstadt	out	29		3	54	13	04		
	in	"	4 44					36	— 50
Vienenburg	out	"		11	40	6	56		
	in	"	12 57					19	1 17
Grauhof	out								
	in								
	out								
	in								
	out								
	in								

46	47	48	Calculation	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Method of despatch (2)	Kind of goods (2)	Tariff kilometres		10	1												1	2	7	
2	3	4 5 6 7									1	4	5							
2	5	3 3 6																		

To be filled in

Owner	Wagon number	Class
Mü	51403	1

according to VZL)

Remarks.

- 1) Enter "R" when wagon shunted for transfer to another train.
- 2) Carry over from column 16.
- 3) Carry over from column 18.

49	50
Total of	
Calculated kilometres (Cols 34, 36, 38, 40 and 42	Calculated running times (h. urs), Cols 35, 37, 39, 41 and 43.
36 37 38 39	
3 3	40 41 42 43
	1 9

To be filled in by intermediate stations :									
41	45								
	a	b	c	d	e	f	g	h	i
	<b>Delays on account of :</b>								
Shunted 1'	Documents missing	Customs	Weighing	Sunday rest	Repairs	Embargo	No room in train	Red-spaced	Other
R									
n									
R	yes				yes				
R				yes			yes		
R					yes				
R									
R									

Punch with									
1	2	3	4	5	6	7	8	9	
44					45				
7	yes			yes	yes		yes		

destination station :

### Description of the system for investigation of wagon movement.

---

Every wagon which is to be observed receives a movement sheet which together with the consignment note accompanies the wagons to its destination.

Special attention is called — by means of various marginal notes — to the 4 main sections of movement, the working up of which is the duty of a special section of the staff. The following are the sections into which movement is divided, for purposes of observation :

- a) Section for the despatching station.
- b) Section for the train journey (inner side).
- c) Section for the intermediate stations at which wagons may be shunted.
- d) Section for the destination station.

a) *Work to be done at despatching station.*

The despatching station has to make out the movement sheet and to take care that the wagon and the consignment note maintain the desired connection.

In the movement sheet heading and on the inner side the owing railway's mark, wagon number and wagon classification number must be entered, and further on in the heading the name of the despatching and receiving stations; further the number of the despatching district and the description of loading places, which latter are divided into free loading roads, private sidings; goods floors, railway loading places, transfer of wagons from foreign lines or transshipment from narrow-gauge lines and other loading places.

The time of placing ready for loading, day and hour, the time of completion of loading time by which free time is exceeded, and the possible causes for delay must be stated; in the last case the principal causes of delay should be specially stated;

b) *Work to be done by the guard.*

- 1. The guard has to check the completeness of the movement sheet;
- 2. See that the wagon under observation is ticketed;
- 3. Fill up such parts of the sheet as are his concern.

This section of the movement sheet is expected to show how the wagon has fared during the train journey, in what class of train it was hauled and what time was occupied in running and in stops.

There must be a fresh entry on the sheet as soon as any essential conditions are varied.

The following information must be entered up :

- 1. Name of despatching station;
- 2. Names of all intermediate stations at which train staff was relieved;
- 3. Names of all intermediate stations at which the wagon was shunted from one train to another;
- 4. Names of all intermediate stations at which delays of more than two hours occurred, when no shunting was done;
- 5. Names of all intermediate stations at which the classification of the train hauling the wagon was changed;

# 6. Name of the receiving station.

Further entries include the mileage run under different classifications and the time occupied in running. All times given for arrival, departure and duration of stops must be actual times and not schedule times.

## c) *Work to be done by intermediate stations.*

The intermediate stations must first of all check the completeness of the movement sheet and then enter whether the wagon has been shunted, *i. e.* transferred from one train to another, and also the causes for delays and here also the principal causes must be enumerated in the sheet.

They must also enter « Yes » if the wagon has gone out later for this cause than it otherwise would have done.

## d) *Work to be done by the destination station.*

The destination station must at once enter up on the movement sheet from the consignment note all such information as cannot be got after the movement sheet has been separated from the consignment note. These are the entries of the loaded weight, method of despatch, kind of goods, and whether they are private, service, or military goods :

For methods of despatch :

Express goods wagon load,

Ordinary goods wagon load,

Special destination wagons for express goods in packages,

Special destination wagons for ordinary goods in packages,

Special destination wagons for dangerous goods,

Tranship wagons for express goods in packages,

Tranship wagons for ordinary goods, in packages,

Tranship wagons for dangerous goods.

Wagons without special destination for express goods in packages,

Wagons without special destination for ordinary goods in packages,

Wagons without special destination for dangerous goods,

Wagons without special destination for milk (including empty cans).

And for kinds of goods :

Manures of all sorts.

Hard coal, coke and briquettes.

Lignite, cokes and briquettes.

Stone of all kinds and broken stone.

Other goods.

The receiving station will then proceed to make out the remaining columns of the movement sheet, enter the number of the receiving district, the weight of load, day and hour of receipt, of the placing for unloading and the completion of unloading, the time in excess of free time, if any, and the time at which the wagon is available for further use or that at which the wagon is sent light to another loading station.

The receiving station, which at last has the necessary time to do so, must now work out, from the entries on the movement sheet, a number of time values showing the periods at loading station, the time occupied in movement at that point, the time taken in placing and unloading at the receiving station and in preparing for reloading or in removing the empty. The totalling up of the guard's entries and the running and stopping times is also the work of the receiving station.

After all columns have been filled up the receiving station must deliver the

movement sheet to the Wagon Office of the Reichsbahn Division concerned.

If a wagon which has been observed in working is sent off by the receiving station as an empty or if it is sent off empty by the Wagon Office, it receives a « sheet for movement of empty goods wagons » which accompanies it to the end of its empty run. The wagon itself is ticketed « Light running research ». The light run as a rule is finished when the wagon is placed for loading at the reloading station.

In exceptional cases the light run is considered as ended if the vehicle stands

more than 24 hours at an intermediate or reloading station or is withdrawn from traffic on account of damage.

The entries in the movement sheet, which takes the same form and calls for the same contents as the sheet for loaded running, are again made partly by the despatching station, partly by the guard and the intermediate stations and partly by the reloading station; they serve as in the case of the loaded running, the object of obtaining the time periods for the separate operations, the classes of the trains by which the wagons have been hauled and the causes of delays.

---

### Express goods central despatching.

The most complete solution of the problem of speeding up and mechanizing the dispatch of express parcels by the adoption of a Central despatching office, is to be found in the main station at Stuttgart, where a new express parcels form has been put into operation with most successful results.

The old express parcels form called for the frequent repetition of many similar entries. It consisted of three sections: one of these was retained by the despatching station as a record, the second was kept at the receiving station, and the third was sent to the consignee with the parcel. The entries on the first were repeated on the second and partly also on the third. The form also called for a large amount of writing work.

In the new form (fig. 16) of express parcel ticket the sections are several superimposed tickets which are coated with carbon on the reverse. The spacing of the lines is standardized in accordance with Din 2101 and 2114. The standardization of the express parcels ticket is under consideration.

The arrangement of the tickets is as follows:

1st ticket, Entries for the express parcel.

2nd ticket, Original of Express parcel ticket (remains at despatching station).

3rd ticket, Delivery receipt (is delivered to the consignor and replaces the receipt book).

4th ticket, The true express parcel ticket (accompanies the parcel; the left section is delivered to the consignee, the

right section is retained at the receiving station).

All entries are manifolded, the receipt book is abolished and the work of writing out is much reduced.

The delivery receipt can be filed by the consignor in his record together with the order and account.

The old type of weighing machine, which was brought into operation by means of a lever has been replaced by an automatic high speed weighing machine. It has duplicate indices, one for the use of the receiving clerk and a second dial from which the sender can read the weight.

To save space, the despatching office has been separated from the receiving office and has been connected to a central despatching department. It has been possible to provide 12 receiving counters (fig. 17) in place of the 8 formerly used.

The senders having large consignments are separated from those dealing with small lots and those sending off the latter are not kept waiting till the larger consignments are dealt with.

When despatching the following is necessary: The entries on the ticket must be checked, the weight must be fixed, the weight and number of packages must be entered on the ticket, and the serial number must be affixed to the parcel.

The express parcel tickets are carried from the receiving counters to the despatching office by a conveyor belt and are arranged on the freight calculator's desks in compartments.

**Expressgutsartie**  
Auslieferungsbescheinigung für

**Stamm zur Expressgutsartie**  
Stammnummer(n) *AAA*

**Stuttgart Hbf.**  
In Firma *Starn*  
Ort *Berlin*  
Wohnung *Friedrichstr.*  
Bestimmungsbahnhof *Berlin Anh. Bahnh.*

**Spielwaren**  
Eichungsbogen über *Holz und Eisenwaren*

**9-10-29** **10:02 10:15:40**

Fig. 16. — Quadruple consignment note for express parcels with carbon-coated reverse side.  
The entries in regard to receipts are manifolded on the corresponding slips.

In the central despatching office (fig. 18), the employees who were formerly divided in separate despatching compartments are now brought together again. And it is therefore possible to adapt the staff to conditions of traffic in a much better way. While formerly the 8 receiving counters called for the employment of a similar number of employees to meet the times of heaviest traffic, 5 suffice under the present arrangements to work out freights, serve the cash registers and take the money. Trained railwaymen are only necessary

to work out the freight for special tariff parcels.

The operation of the cash registers and the receipt of money can be left to unskilled staff.

The cash register prints at one operation the original of the express parcels ticket, the consignor's receipt and the express ticket itself with the following entries: Day, month, year, serial number, weight, time of day to nearest five minutes, despatching station and freight. Similar entries with the excep-



17. — Express parcels acceptance stand (goods station at Stuttgart) with belt conveyor for sending the documents to the central goods office.

tion of day, month, and year are printed on a control strip.

The control strip replaces the sales book in which entries were formerly made of all consignments with number of package, weight, freight and payments. This book was kept in the custody of the office chief.

The cashier sends the delivery receipt stamped by the cash register to the consignor for the payment due for freight. In the case of multiple consignments the cash register prints a so-called summary

check for the total of freight due on all consignments. The consignor can check the amount shown on the summary check by the delivery receipt which is also sent him.

The cash register adds cash receipts divided into totals for turns of duty and for different cashiers and the total shown on the control strip must be made over by the cashier concerned.

The change machine increases the speed and the accuracy of the cashier's work. He has only to pay in the amount



Fig. 18. — Central express goods despatching office:  
Freight calculator.

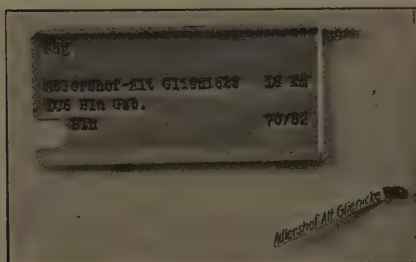


Fig. 19. — Address plate with identity badge  
consignment note checking.

due for freight to the machine and the machine throws out the difference between the amount paid by the consignor and the amount of the freight, automatically.

As soon as the freight is paid, a conveying belt running under the cash counter delivers the express parcels ticket to the loading place.

The new express parcels despatching system has assured the prompt acceptance and despatch of parcels even in times of peak traffic.

Consignors can see the acceptance times which are printed on the receipt

ticket by the cash register, and are thus able to check the expenditure of time by their employees and vehicle drivers.

In this way both the Consignors and the Railway save money and time.

This new manifolded express parcel ticket has been introduced at many stations on the Reichsbahn. It is to be put into use at all stations as from 15th November 1929.

The central system of handling, despatching with conveyor, cash registers and change giving machines will be provided from time to time at all stations with heavy express parcels traffic.

### Checking of consignment note at goods stations.

The consignment note is checked before acceptance of the goods.

Special checking stations have been set up at the larger goods depots for this purpose. The division of the work in checking consignment notes on one side and acceptance of consignment notes and goods on the other has speeded up and simplified the work of receiving consignments. The checking stations decide if the goods can be sent by rail, if the consignment note is properly made out, especially if the name of the destination station is correctly filled in. They enter from the station tariff the manner of loading, the distance and, in the case of goods in packages, the tariff classification and freight charge. This saves the freight calculator the trouble of looking up the mileage and freight rates.

In order to make the settlement of loading, mileage and freight quick and easy, the checking stations are provided with clearly arranged tables from which the required information and figures can be at once obtained. Mileage and freight charges are stamped on the consignment note with rubber stamps. The rubber stamps are kept for the stations most frequently in use in a fixed order; their size however prevents their being kept in a big goods station in sufficient numbers, so that a majority of the consignment notes must be filled up by hand.

At the speed at which these entries must be made in order to cope with the number of consignments offering at certain hours, errors easily occur in making references and insufficient or illegible entries are made. This leads to delay or missending of consignments. In ad-

dition writing by hand is slow and this loss of time is especially noticeable in the evening when the rush of traffic is greatest. Considerable increase of speed and accuracy can only be attained by the mechanization of the checking.

The addressing machine arranged as a single printer meets requirements in this direction. The basis of the system is the address plate (fig. 19). The space to be seen in the bottom left hand corner serves for the control stamp of the checking employee.

The stamp is interchangeable; it is placed in the machine by each checking employee on beginning his turn of duty and it is printed on all the consignment notes checked by him; on leaving duty the checker takes out his stamp which is replaced by that of his successor. In this simple way the checker can be identified at any time. The top part of a consignment note bearing the printed checker's stamp and the control mark is shown in figure 20.

The plates are stored in cupboards in alphabetical order of station names. Each cupboard holds 600 plates. As a rule 7 cupboards make up one lay-out, so that 4 200 plates in the cupboards can be placed within reach of the employee (figs. 21 and 22).

The name of the destination station is written on a little badge in legible characters on the narrow edge of the plate turned towards the front of the cupboard. The plates for package goods have white badges, while those for express parcels have black writing on red badges. In order that the plates may

emark. The parts between heavy lines are for the entries of the railway; the remainder is to be filled in by the consignor

Nr.	Despatched	Re-charge for customs duty or taxes.
	to .....	
	via .....	

Only to be filled in by consignor  
when he loads the goods himself:

Number	Owners mark	Weight tons	O (open top) or U (cover- ed wagon)	Tare in kgr. (for private wagons)
	of wagon.			
.....				
.....				
.....				
.....				
.....				
.....				

### Destination station.

If necessary, directions for trans-  
shipment (for example, by narrow  
gauge line to.....).

## Consignment note

(Conditions of transport are regulated by the Railway Traffic Order and the tariffs to be taken into consideration, = Traffic between East Prussia and other parts of Germany is governed by the Agreement with Poland and the Free Town of Danzig relating to transit traffic).

To .....

At .....

(Residence) .....

Fig. 20. — Top part of consignment note.

be quickly and easily removed from the cupboards they are fitted with small grips.

Printing is carried out in the following manner: The plate for the destination station is taken out of the cupboard and pushed into the head of the single printer. The necessary entries for the destination station are then printed in the space provided on the consignment note by a simple pressure of the foot. The plate is at once returned to the cupboard, taking care to see that it is replaced in its original position, so as to keep the plates always in the same order.

The single printer has the following advantages:

1. The bad and illegible hand writing

is replaced by clear and clean print for the work in connection with consignment notes, which makes the multiple manipulations of these notes quicker and easier.

2. The search for mileages and freight rates through voluminous tariff lists is saved.

3. The entries printed with the destination station are absolutely correct (distance, rate, etc.) and form the reliable basis for calculation of freight charges.

4. The destination station is relieved from the necessity of checking mileages and rates.

5. The advance checking of the consignment note is appreciably speeded up.



Abb. 21. — Pedal address printer and cupboard  
for storing 2400 addressplates.



• Fig. 22. — Installation for checking invoices (goods despatching office,  
Berlin-Anhalt.

# REPORT N° 5

(Germany)

ON THE QUESTION OF SIGNALLING OF LINES FOR FAST TRAFFIC AND IN MAIN STATIONS. DAYLIGHT SIGNALS. AUTOMATIC BLOCK SYSTEM (SUBJECT XI FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION <sup>(1)</sup>),

by W. STÄCKEL,

Reichsbahndirektor, Member of the Headquarters Administration of the Deutsche Reichsbahn Gesellschaft (German State Railway Company).

Figs. 1 to 30, pp. 993 to 1027.

## PREFACE.

As a basis for the discussion of signalling methods on lines carrying fast-moving traffic, a very interesting review was given at the last session of the Congress, held in 1923, of the signalling systems in force in a number of the countries taking part in the Congress. The information alluded to above is supplemented in the following by a similar review of the German signalling system, which differs fundamentally in several respects from the systems already reported upon. In addition an account is given of the experience gained by the Deutsche Reichsbahn with daylight signals and automatic block working.

## CHAPTER I.

### Principles underlying the signalling system adopted on the main lines of the Deutsche Reichsbahn.

#### A. — Signalling system.

##### 1. — Home and distant signals.

The fixed signals used in Germany for railway traffic are the so-called home or

main signals, which serve to protect railway stations or block sections or sometimes to cover particular danger points, and further distant signals, which are placed at a suitable distance in the rear of the home signal. These latter serve to prepare or to warn the driver of the approaching home signals (fig. 1).

The home signals indicate « danger », by day, by means of a horizontal arm placed to the right of the signal post. At night time they show a red light, and with very few exceptions this is the normal state of the signal. For the « line clear » position the arm slopes upwards to the right and at night a green light is shown. The height of the home signal is chosen in such a manner that it can be seen from as great a distance as possible. For this reason the height is in some cases as much as 15 m. (50 feet) and more.

On the other hand, the distance at which the distant signal is visible is not given much consideration but much more importance is given to ensure that it will catch the driver's eye, even in foggy weather. This requirement prevents the placing of distant signals at considerable heights and leads to the

(1) Translated from the German.

placing of the signal as nearly as possible at the level of the eye of the engine driver. According to experience gained in Germany, disc signals are particularly

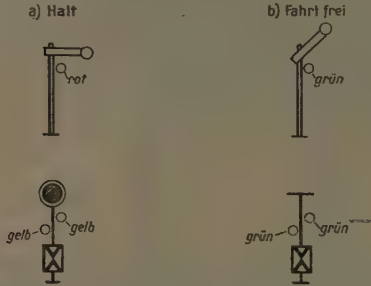


Fig. 1. — Home signal and distant signal.

Explanation of German terms: Halt = Stop. — Fahrt frei = Road clear. — Rot = Red. — Grün = Green. — Gelb = Yellow.

favourable for this purpose. For this reason when the home signal is at danger, the distant signal is made in the form of an enamelled yellow disc of 1 metre (39 3/8 inches) diameter, and this is always placed close to the right hand side of the track. This type of disc possesses great visibility even with a dark background and under poor lighting conditions. As will be seen in figure 2, even when the space between tracks is so small that a signal bridge or gantry has to be used, the disc can be brought sufficiently close to the view of the driver.

When the home signal stands at line clear, the distant signal disc is moved through 90° about its horizontal axis. Some experts consider this arrangement as unsatisfactory from the theoretical

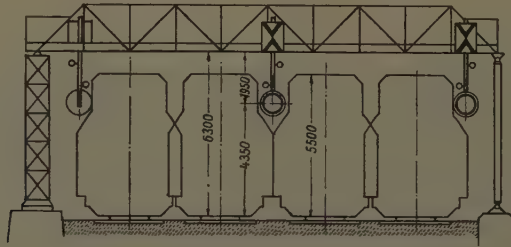


Fig. 2. — Signal bridge with distant signals.

point of view, because apparently the signal offers no surface which will render it visible to the eye. It is true that when the line is clear there is no immediate danger in overlooking the distant signal, but it might have a disturbing effect on the driver. For this reason a very noticeable mark, consisting of a black St. Andrew's cross on a white background is mounted on the post carrying the signal, and by means of this the driver can be sure of picking up the distant signal. . . .

Once it has been sighted, experience goes to show that there is no difficulty in recognizing whether the disc is turned over or is in the vertical position. In order to assist in picking up the distant signal in the open country, the practice adopted in Belgium and Holland was introduced in the year 1926 and consisted in placing from 3 to 5 warning boards in the rear of distant signals applying to home signals at entrances to stations or sections. The arrangement is shown in figure 3.

The general arrangement of the distant signal and its accessories has the great advantage that special warnings in foggy weather (detonators) can be done without. This is an important matter in Germany on account of the climatic conditions, because, on the one hand fog is not so frequent in that country as to justify special gear and a special organization for putting down detonators, while on the other hand it is necessary to provide sufficient protection against the evil of occasional fog.

As regards night signals, great importance is attached in Germany to the necessity of avoiding the use of the same light for different signal indications, while on the other hand the number of suitable signal colours is limited to three (red, green, yellow). It has therefore been necessary in some cases to have recourse to double lights.

When the home signal is at danger a red light is shown and the corresponding signal on the distant post is given by two yellow lights placed obliquely. For line clear the home signal shows a green light and the distant signal two green lights placed obliquely. The requirement that each kind of signal should be indicated by a different sign is thus fulfilled. The object in doubling the yellow lights was to prevent confusing red and yellow.

## 2. — Spacing of signals.

The standard distance between distant and home signals on the German State Railways is 700 metres (2 296 feet). On rising gradients and at such places where the distance necessary to stop a train by braking is substantially less than under normal conditions, it is permissible to reduce the spacing. An increase in the

space between distant and home signals up to 1 500 metres (4 920 feet) is per-

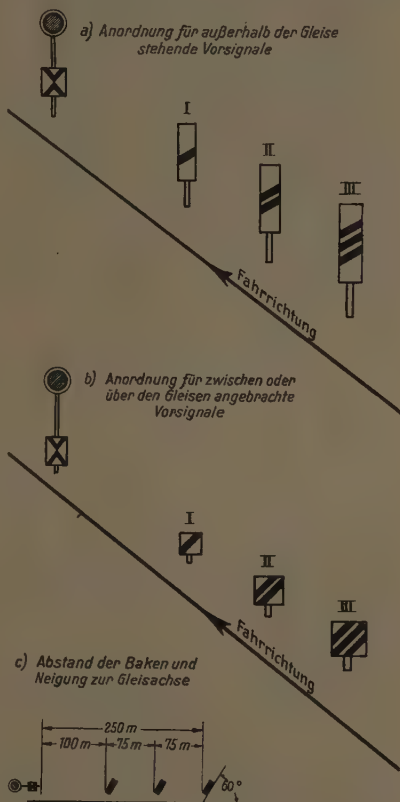


Fig. 3. — Warning boards preceding distant signals.

Explanation of German terms: a) Anordnung für ausserhalb, etc. = Arrangement for distant signal-placed outside the track. — b) Anordnung für zwischen oder, etc., = Arrangement for distant signals placed in the four-foot or above the track. — c) Abstand der Baken, etc., = Distance between boards and inclination on the center line of the track. — Fahrrichtung = Direction in which trains run.

mitted, if thereby it is possible to combine the distant signal with the home

signal in the rear, thus simplifying observation of the signal.

Whether with a further increase of the speeds of express trains the spacing of 700 m. (2 296 feet) will suffice in the future, depends on developments in the braking equipment of the trains. Under present conditions the spacing of the distant signal of 700 m. gives ample security for speeds up to 100 km. (62 miles) per hour, with the usual braking equipment and when using coaches having a corresponding braking capacity. A greater speed is only permissible if the train is equipped with quick acting brakes of the latest design.

The distance prescribed between the home signal and the danger point is 50 m. (164 feet) as a minimum. This space is however increased, if the first danger point after the home signal is a crossing or if for any particular reason there is special danger of over-running (fig. 4).

On lines which have been experimentally arranged for automatic train control, the distance of the home signal from the danger point has been in part fixed under special rules having reference to the method of operation of such installations. So called overlap block working, that is to say the clearing of a whole block

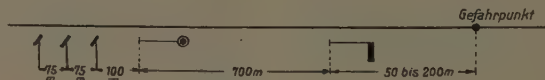


Fig. 4. — Protection of a danger point.

Explanation of German terms. — Gefahrpunkt = Danger point.

section ahead of the home signal when a train is approaching it is only introduced here and there at specially dangerous points.

### 3. — Indication of diverging routes.

A specially difficult signalling problem arises at those points where the tracks divide into branches in advance of the signals. Under the well-known bracket or geographical system, which is adopted in several countries, a separate signal post for each branch road is mounted on a bracket.

The signal aspect is formed horizontally. When the branches originate in several tracks, it is necessary under this system to supply a separate bracket for each original track which carries the horizontally disposed short signal posts (or dolls). As against this horizontal system an arrangement is adopted in Ger-

many which may be described as the vertical system. Here again there is a signal post for each originating track, but the arms referring to the different branches are arranged vertically one above the other. Signals with two and three arms are in use at branches, according to whether one or two branches from the straight through track are to be signalled. The different signal arrangements of a 3-armed home signal are shown in figure 5. A particular feature of this type of signal, in which it differs from the practice of most other railways, consists in the fact that those signal arms which for the time being do not form part of the signal indication or aspect, do not stand in the horizontal position but vertically in front of the post and that at night the corresponding signal lamps do not show a red light but are covered up.

The object of this arrangement is to prevent the appearance on the particular

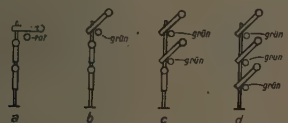
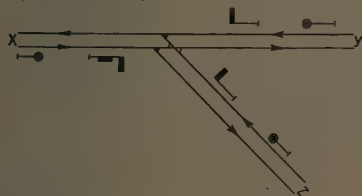


Fig. 5. — Three-arm main signal.

a) Signale in Grundstellung



b) Fahrt von X nach Y und von Y nach X



c) Fahrt von X nach Z und von Z nach X

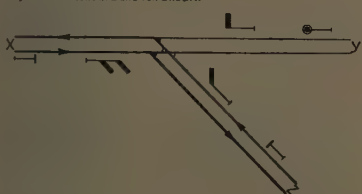


Fig. 6. — Branching off point.

Explanation of German terms: a) Signale in Grundstellung = Signals in normal position. — b) Fahrt von X nach Y und von Y nach X = Trains moving from X to Y and from Y to X. — c) Fahrt von X nach Z und von Z nach X = Trains moving from X to Z and from Z to X.

signal post in question of a danger signal alongside the line clear signal, and

further that when a danger indication is to be shown there should be no needless multiplication of danger signals.

Figure 6 shows the arrangement of signals at a junction between stations. Branches at the entrance or exit to or from a station are treated in a similar manner.

In figure 7 is shown the arrangement of signals as it would be in the German

a) Dreiflügelige Signale



b) Kandelabersignale



Fig. 7. — Signals at branching off points.

Explanation of German terms: a) Dreiflügelige Signale = 3-arm semaphore. — b) Kandelabersignale = Bracket mounted signals.

system for signalling a junction of three original tracks each leading to the same three destinations. It will be recognized that under the most unfavourable conditions that is with a 3-arm signal all set at line clear, the whole group of signals would show only five, or in the most favourable conditions, not more than three signals or signal lights. Opposed to this the same figure illustrates a bracket system for the same conditions, where in every case the group of signals will show nine indications crowded very close together.

As regards observation of the signals, where several directions of origin are involved the vertical system practised by the Reichsbahn is more easily seen than the bracket system.

In Germany so far there has been no indication given by the distant signals as to whether it is the straight through line or the branch line which has line clear. However, experiences gained in operation tend more and more to the conviction that for express traffic lines a distant signal giving three indications is very desirable.

## B. — Arrangement of signals at stations.

### 1. — *Fundamental considerations.*

In equipping German stations with signals, the tendency of late has been to reduce the number of signals to a minimum. Apart from the fact that in signalling the greatest possible simplicity increases the general visibility, there are in Germany special reasons which make it desirable to make it as easy as possible for the drivers to pick out the signals.

This is due to the fact that of late years it has become the practice to an increasing extent to arrange for the crews of the locomotives to take duty on long sections; and in addition the sections on which they have to do duty are frequently changed according as it fits in with the arrangements for the locomotive service. Thus it follows that drivers who are stationed at central points on the system have to be familiar with a considerable number of roads which may, in part, be of considerable length and over which they may only have to run trains at fairly long intervals. This circumstance is as far as possible taken into consideration in the lay-out of signals.

### 2. — *Home and starting signals.*

In view of the foregoing considerations, it is always the aim to manage with only one home signal at the end of each section which terminates in a station, even if in approaching the station several signal cabin zones have to be traversed. This is possible by electrically interlocking the different signal cabins on the block system, either directly or through an intermediate control. The same method is adopted for each road leading out of the station where, if possible, only one home signal is provided both as starting signal and for protecting the departure route, and likewise to cover the first block section beyond the station. Hence, the starting signals are placed before the point where the tracks run together to form the single or double line as the case may be.

### 3. — *Distant signals in conjunction with starting signals.*

In order to make matters safer for non-stop trains running through the stations, many of these latter have distant signals applying to the starting signals. They are arranged just behind or at the side of the home signals at the entrance to the stations.

The possibility of doing without the distant signal applying to a starting signal was considered, and this was to be done by imitating the practice of some other railways where the distant signal for the home signal at the entrance to the station is used for giving « line clear » to a non-stopping train, that is to say, the distant signal would only be placed at « line clear » when both home signal and starting signal are at « line clear ». This arrangement would have the following

disadvantages if applied to German operating conditions:

1. Trains which are scheduled to stop at the station would frequently find the distant signal against them and this would cause the driver to slow down before his time even if the road was clear. Trains which finished their run at the station would of course always find the distant signal against them.

2. With an arrangement of this kind the meaning of the different distant signals which the driver would have to observe during the course of his run would not always be the same. Some of the distant signals would refer only to the nearest home signal whereas others might refer to two subsequent home signals. As against this the simple principle is now in force, in Germany, namely, that every distant signal refers only to the home signal immediately ahead of it.

3. The distant signal controlling the entrance to the station would under dense traffic conditions, be against the non-stopping trains in most cases, because the block section beyond the station would often be still occupied at the time when the particular train was approaching the signal at the entrance to the station.

The separate distant signal for the starting signal was therefore decided on. If this distant signal is placed adjacent to the home signal, the wellknown rule observed by the English system of signaling, namely, that the distant signal may only give line clear when the adjacent home signal is likewise at line clear, is similarly enforced in Germany. Accordingly the distant signal for the starting signal is electrically and mechanically interlocked in such a manner, that it is dependent on the position of the home

and starting signals and can only give « line clear » according to which of the two former signals has been last placed in that position (*i. e.* « line clear »).

The combination of a 2-arm home signal with one distant signal for the starting signals enables five different signal orders to be conveyed, namely:

- a) Stop.
- b) Entrance to the through line clear, warning to look out for starting signal at stop.
- c) Entrance to the through line clear, starting signal will be at line clear.
- d) Entrance to branch line clear, warning to look out for starting signal at stop.
- e) Entrance to branch line clear, starting signal will be at line clear.

#### 4. — Protection for shunting operations.

A peculiarity of the Reichsbahn signaling is the fact that the main signals only refer to running movements. Hence shunting trains are allowed for example to pass a starting signal which stands at danger without any special formality. The use of the home signals for protecting shunting operations could be disregarded all the more, because the principle of interlocking signals and points as practised in the case of running movements has not been adopted for shunting. The control of shunting operations is mostly accomplished by hand and audible signals. In order that shunters may satisfy themselves that the points are in the correct position, all points which are not used exclusively for running movements, are provided with point signals. These consist of opal glass signs on a black background and are illuminated at night. In addition, in order to



Fig. 8a. — Shunting protection signal  
(line blocked position).



Fig. 8b. — Shunting protection signal  
(line clear position).



Fig. 9. — Application of shunting protection  
signals.

protect trains running through places where shunting operations are in progress, a so-called shunting stop signal (fig. 8a and b) is erected. This consists of a black bar on an opal glass background, which is illuminated at night. When the line is blocked the bar is horizontal; when the bar is shown sloping upwards the signal may be passed. Figure 9 shows a case in point.

With the system of point indicators there was formerly the important defect, that at places where there were double slip points, there was an accumulation of signals which made it very difficult for shunters to pick out the setting of the



Fig. 10. — Signals for double  
slip points.

signals, because each pair of points in a group of double slips had a separate point indicator, that is to say, there would be four point signals. In the course of

the last few years a special point signal, invented by Professor Cauet in Berlin, has been introduced and in this the four signals previously used are replaced by a single signal as may be seen in figure 10.

The white bars of the signal indicate roughly the plan of the roads commanded by the double slip points.

### C. — Exceptions.

The foregoing details do not give a complete picture of the German signalling system, inasmuch as in certain districts of the Reichsbahn there are departures from the general rules of signalling and there are special types of signals still in existence which date from the period when a uniform system of signalling had not yet been introduced. A detailed consideration of these exceptional cases is however beyond the scope of this report.

### D. — Plans for the further development of the signalling system in Germany.

The German signalling system, like most other European systems has sprung from conditions of operation and from lay-outs which in comparison with existing conditions, called for much less stringent treatment of the means adopted for safe working. Moreover, at that time experience was lacking which was only later on gained as a result of accidents on the railways.

In spite of some very important improvements introduced round about the close of last century, the necessity has once again arisen in Germany to-day of modifying the signalling system to bring it into line with existing conditions of operation. In considering at this point the question of further development of the signalling system, we are following the

example of the Italian State Railways, whose schemes for future development submitted to the Congress in 1925, aroused great interest. The problem of modernization would be most easily solved, if it were possible to abolish at one blow all the existing signals and to replace them by an entirely new system. Such a proceeding might under certain circumstances be feasible with a small railway system, but in a great and complicated system, such as the Reichsbahn, a sudden change of this nature is prohibited for operating reasons alone, quite apart from the question of economy. A gradual development is indicated and it would appear desirable in proceeding with this to observe the following rules :

a) The indication which is given by an existing signal can only be altered, if the alteration can be carried out simultaneously over the whole railway system; such an alteration can therefore only come under consideration if the necessary engineering work in connection with such alteration is relatively slight.

b) If a signal is to be replaced by a different one, both to have the same meaning, it will be necessary during the transition period for the old signals to be used simultaneously with the new ones. On the other hand, the continued simultaneous existence of two different signals having the same meaning ought to be avoided.

c) New signal meanings must be expressed by *new* signals, unless under the conditions mentioned in a) an existing signal may have its meaning changed.

The collation of these conditions is of some interest in the international treatment of the signalling question, inasmuch as it shows to what a great extent in this connection the future depends on

the past. This unfortunate dependence makes many solutions of the problem for individual important railway administrations impossible, although such solutions may be intrinsically suitable, and it prevents the general and uniform application of the principal signals to the systems in different countries.

The following improvements have, in the course of time, been shown to be desirable in connection with the signalling system of the German State Railways :

*a)* Introduction of a distant signal with three meanings, which would indicate « prepare to stop » (caution), « prepare for line clear to branch line » and « prepare for line clear on the straight through line ». The question was considered of providing for this purpose a signal arm in three positions. The consideration that on the less important lines an alteration of the distant signal is not called for and the view that the yellow disc, as a warning, mounted on a short post had justified its utility, seemed to indicate a closer adherence to the existing distant signal as being desirable. Above all the « caution » indication will presumably remain unchanged. For the meaning « prepare to run on to branch line » it is highly desirable that a signal shall be used, which strikes the eye of the driver just as effectively as the caution signal, because in fast running trains the difference between the braking distance for a stop and that required for slowing down to branch points, is comparatively small. Two distant signals with three meanings, selected from a large number of designs are shown in figures 11 and 12.

For the hours of darkness the following arrangement is proposed :

Warning : 2 yellow lights.

Branch line : yellow-green.

Line clear on the straight through track : two green lights.

All three pairs of lights being arranged obliquely. This grouping of lights, in itself simple enough, was open to the objection that if the yellow light of the yellow-green signal failed, that part of the signal which conveys the warning would be eliminated and the driver might take the green light which remained as part of a double green signal. It was therefore provided that only the lower lamp of the two should have a light, while the upper lamp receives its light by an arrangement of mirrors.

*b)* Alteration in the meanings of the home signal, involving, a change from the principle of indicating the road, to the principle of indicating the permissible speed.

With the present arrangement of signals the question, if the signal controlling the entrance to a station road is to be indicated by one or more arms on the home signal, depends upon whether it is run through on the straight through or main track, that is the track allotted to non-stopping trains, or whether it is a case of running on to another set of rails.

As a rule the main straight through track has a straight or slightly curved run, whereas the entry to other tracks is made over points with short curves.

The engine driver thus has the understanding, that the one arm signal allows him to run on without slackening speed, whereas the signal with several arms calls for a reduction in speed. It is true that in a small minority of cases the main track is likewise carried over points and short curves; in certain cases it even happens that the straight through road leads to the branch line while the main track is carried over points and short

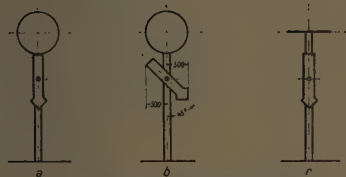


Fig. 11. — Disc distant signal with additional arm.

- a) Warning.
- b) Prepare for « line clear » on branch line.
- c) Prepare for « line clear » on through line.



Fig. 12a. — 3-aspect distant signal of the disc type (Oldenburg pattern). — Warning.



Fig. 12b. — 3-aspect distant signal of the disc type (Oldenburg pattern). — Prepare for « line clear » on branch line.



Fig. 12c. — 3-aspect distant signal of the disc type (Oldenburg pattern). — Prepare for « line clear » on the through line.

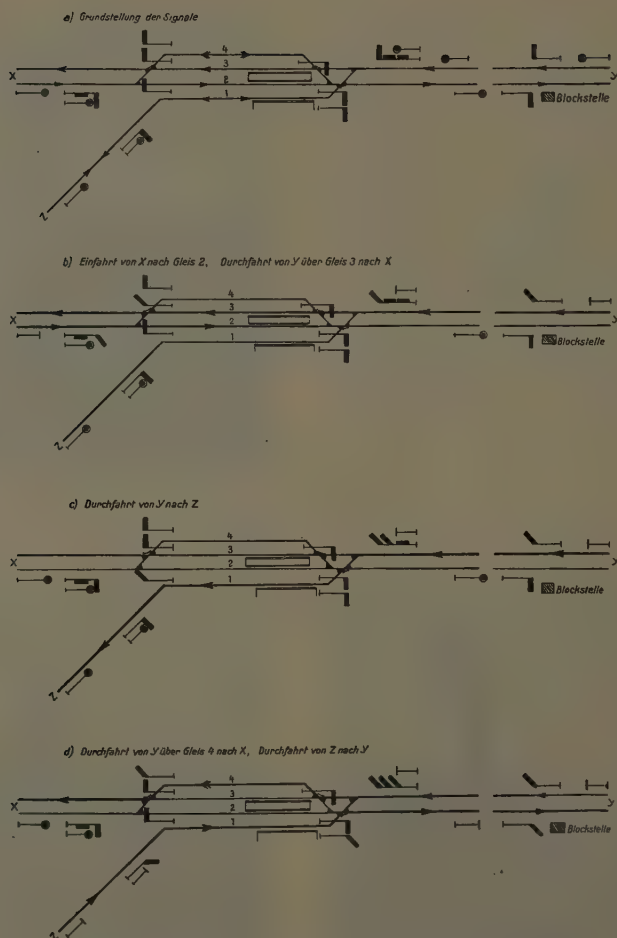


Fig. 13. — Present-day arrangement of signals in a station.

*Translation of explanation (downward):*

- a) Normal position of signals;
- b) Entrance from X on line 2; Non stop passage over line 3 from Y to X;
- c) Non stop passage from Y to Z;
- d) Non stop passage from Y to X over line 4; non stop passage from Z to Y.

*Explanation of German terms: Blockstelle = Block post.*

curves. In such cases, if the driver does not pay careful attention, the present system of signalling may be misleading and it is therefore intended to give the home signal the following meanings in the future : One arm : « line clear »; two arms : « line clear with speed reduction », that is to say the principle of indicating the road, is replaced by a system which indicates the proper speed. The 3-arm signal is to be done away with in the course of time.

It is further intended to reconstruct as 2-arm signals those signals which do not govern a branch connection, but which are followed shortly by points which have to be taken at slow speed. Figure 13 shows an example of the arrangement of signals at a station under the existing system, while figure 14 shows for the same station the signals arranged on the principle of speed indication.

Certain difficulties were recognized when working out a scheme on this principle for the different sets of rails at larger stations. The principle of speed indication as described above necessitates the abandonment of any distinguishing indication differentiating the tracks of a group over all of which a speed reduction is necessary. In special cases, however, it is possible for the individual tracks under this heading to be laid out in such a different manner that the driver must unquestionably be able to recognize which road he is intended to take (route indication). This distinction, once the principle of speed indication is accepted, is not to be effected by means of signal arms or coloured lights, but by the application to the signal post of a route indicator, which would only apply under special circumstances.

The route indicator shall either consist

of figures which are illuminated at night time, similar to arrangements existing in England and Belgium, or a combination of white bars, lit up at night, in place of figures. The route indicator is not intended to be seen at a distance.

The following considerations form the basis of this arrangement :

When approaching a home signal, the driver need only recognize from a distance whether he may run through the station at full speed or whether he must slow down. In the first case a route indicator does not come into consideration; in the latter case he will have no difficulty in recognizing the figures or the bar signs as the case may be, because he will be passing these at reduced speed.

c) It is felt that a defect of the signal with several arms consists in the possibility of mistaking the signal when some of the arms may be hidden by bridges or other obstructions and especially at night should a signal lamp go out. It is therefore necessary to endeavour to replace the arrangement of signals having several arms by a single arm signal.

Investigations are proceeding which aim at the following system for future adoption, in which single arm signals would be employed exclusively :

Arm set obliquely upwards — green light — « line clear »;

Arm horizontal — red light — « stop »;

Arm set obliquely downwards — two yellow lights one above the other — « line clear with reduced speed ».

This arrangement would enable a gradual change over from the present system to be made without too extensive alterations, for the reason that the two first mentioned positions which come most frequently into operation, do not

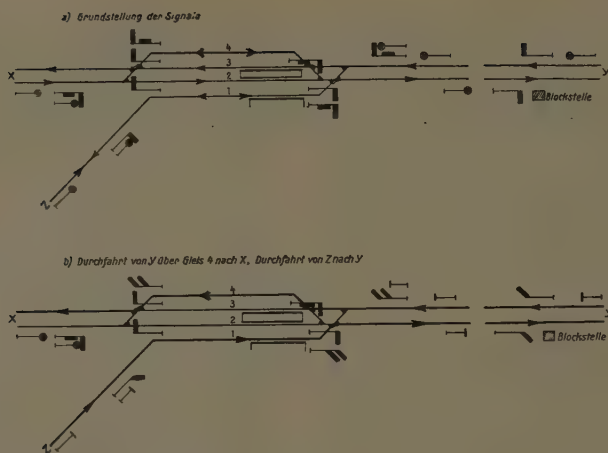


Fig. 14. — Projected arrangement of signals in a station.

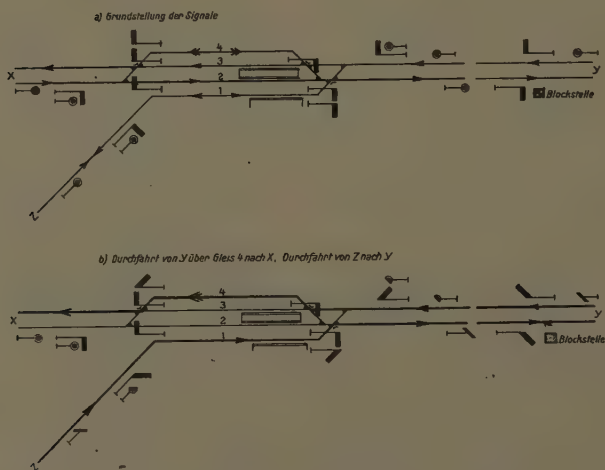


Fig. 15. — Arrangement of signals in a station.  
3-aspect main and distant signals.

constitute any change from the existing state of affairs.

Figure 15 shows how this 3-position

arrangement of the home signals would appear in conjunction with the distant signals which give three indications.

## CHAPTER II.

**Daylight signals.**

The Reichsbahn started to employ colour light signals in 1924. The immediate cause of this was due to the fact that on certain sections, where electric traction had been introduced, the proper observation of signal arms was rendered very difficult by the structures carrying the overhead line. To a certain extent this defect could be met by employing cantilever structures in place of the lattice-work gantries in order to make it easier to see through the supporting iron-work, and in addition by placing the vertical supports in such a way as to give a clear view of the signals.

A really satisfactory solution could, however, only be achieved by using signals of different design and which would stand out in much greater relief from the multitude of wires than the semaphore signals. This consideration led to an experiment with daylight signals.

**A. — Trial installation in Silesia.****1. — Characteristics of the trial section.**

The choice of the first trial section was governed by the desire to obtain an opinion as to the general applicability of this type of signal to the Reichsbahn and the section was not chosen because it was particularly suitable for showing the value of daylight signals.

From this point of view, therefore, it was necessary to choose a section, which by reason of its particular attributes would constitute a severe test of the daylight signals. The section Hirschberg-Königszelt in Silesia which is electrically

operated was therefore chosen and this section has the following characteristics :

- 1) Curves of small radius;
- 2) The line runs through mountainous country, hence at many points dark woods form the background;
- 3) Heavy snow in winter; background and light conditions are totally different when snow has fallen;
- 4) Express traffic with maximum speeds of 90 km. (56 miles) per hour and in addition heavy goods traffic.



Fig. 16. — Daylight signal.  
Home signal and starter on the same post.

An example of the colour light signals installed on the Silesian trial section is shown in figure 16.

For purposes of comparison a second trial section was chosen on the electrically operated suburban railway Berlin-

Lichterfelde (Ost), which in contradistinction to the first-mentioned section imposes much less severe conditions on the daylight signals.

## 2. — Optical design.

The difference between the daylight signals and the usual light signals used at night consists, as is well known, in the materially stronger concentration of the light used for the daylight signal. The cone of light is therefore much more acute than is the case with the ordinary light signal. This concentration of the light is the means by which the remark-

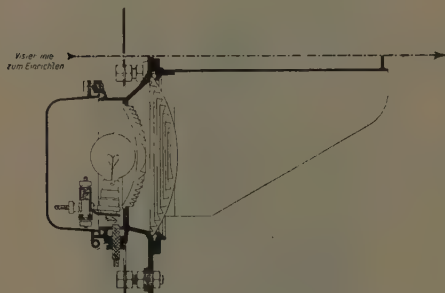


Fig. 17. — Old type of daylight signal.

Explanation of German terms: Visierlinie zum Einrichten = Sighting line for adjustment.

able effect of the luminous signal in daylight is produced; at the same time this concentration introduces a number of difficulties.

Whereas there is no difficulty in making the ordinary signal lights visible on curves on account of the considerable dispersion, the daylight signal is a distinctly tough problem on curves, because beyond the narrow cone of light the signal becomes entirely invisible to the eye of the observer. It was therefore not surprising that on the Silesian trial section with its heavy curves the first experiment with

daylight signals constructed according to the then existing design, as shown in figure 17, was not successful.

Whereas the effect of the signal at the centre of the cone of light was so powerful, that the eye suffered noticeably from the glare, it fell off so quickly at a slight deviation from the centre on the curve, that the light effect failed to make the signals sufficiently noticeable. Comparing them with the old type arm and disc signals, which were left standing during the trials, the impression that the old signals, when approached on the curve, were more effective than the daylight signals, could not be denied.

The problem was therefore, by suitable design of the optical system, to materially increase the effectiveness of the signals on curves. For this purpose two methods were adopted by the manufacturers Messrs. Siemens and Halske, the effect of which is graphically illustrated in figure 18.

An hemispherical bull's-eye lens with internal dispersion grooves (figs. 19a and b) was moulded so that :

1. the disagreeable glare at the centre of the cone of light was reduced and the light thus saved was distributed laterally and
2. the cone of light was flattened out, at the same time reducing the dispersion upwards and downwards.

Further the light was concentrated as much as possible at the focal point of the lamp by means of a filament of the projector type and, a very important point, considerations of economy in current consumption were allowed to give way to reliability of the signals.

The Osram-Nitra lamp which is used consumes 40 watts at 12 volts. The colour

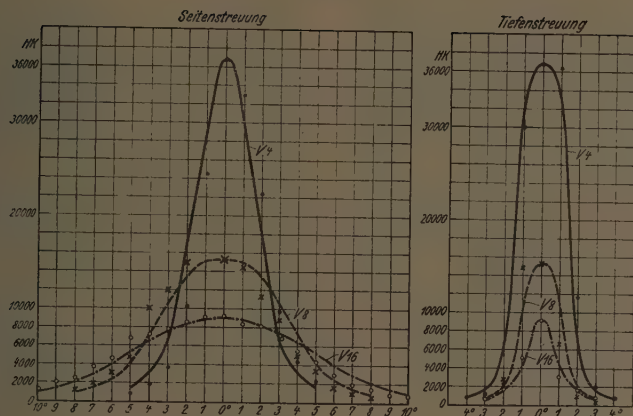


Fig. 18. — Photodiagram obtained by means of lenses with various lateral and vertical dispersion.

Explanation of German terms: *Seitenstreuung* = Lateral dispersion. — *Tiefenstreuung* = Vertical dispersion.

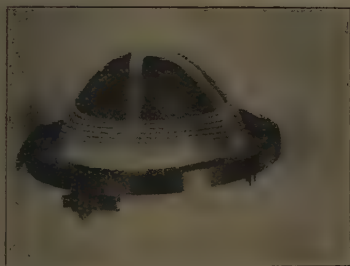


Fig. 19a. — New lens (Siemens & Halske).

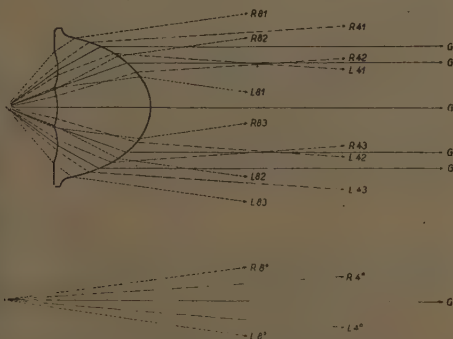


Fig. 19b. — Projection of light beams by the new Siemens & Halske lens.

effect is produced by a coloured disc between the lamp and the lens.

The following further steps were also taken to improve the conditions:

According to the curvature of the section three different types of lenses were employed, one with an angle of disper-

sion of 4 degrees (type V. 4) one with 8 degrees (type V. 8) and one with 16 degrees (type V. 16) (see corresponding 3 curves in figure 18). This graduation is based on the consideration that on a curved section the prescribed reduction in speed leads to a shorter braking distance

so that the signal need not be visible at as great a distance as on a less curved portion of the line, and furthermore this distance is the less, the sharper the curve. The light gained by reducing the distance effect can thus be utilized for increased lateral distribution.

### 3. — *Visibility of the colour light signal.*

By the help of the above-mentioned devices it has been possible to fulfil the following conditions in a thoroughly satisfactory manner :

1. On the straight, provided there is no mist, the signal is easily seen at a distance of 1 000 m. (3 280 feet).



Fig. 20. — Determination of sighting distance in a curve.

2. On curved sections in clear weather the signal can be depended on to give the full designed angle of beam and, even at the extreme edge of this angle, the light effect in very bright daylight is still so powerful that the signal strikes the eye of the observer unmistakably. A simple mathematical calculation will give the distance at which a light signal will be observable on a curve of given radius, and

without the signal again being lost to view on approaching more closely.

For example, as will be seen in figure 20, a signal with the 16° lens can be seen on a curve of 500 m. (25 chains) radius at a distance of 260 m. (852 feet).

This suffices amply to pick up the distant signal with certainty in view of the limiting speed of 85 km. (52.8 miles) per hour which is imposed on curves of 500 m. (25 chains) radius.

The distance from which the 16° lens signal can be seen when running on a curve of 300 m. (15 chains) radius drops to about 160 m. (520 feet). This is the sharpest curve likely to come into consideration in general practice. This distance is however ample for observing the distant signals, because the speed on such a curve is limited to 65 km. (40.4 miles) per hour. Under certain circumstances the distances do not quite suffice to enable a home signal, unexpectedly indicating for a branch line, to be sighted in time to reduce speed sufficiently. This defect however can be met by moving the home signal a little further away from the point where the line branches.

For this reason in future the use of the 30° lens, designed by the Allgemeine Elektrizitäts Gesellschaft for sharp curves, will be abandoned with a view to reducing the number of different types of lanterns.

In future only two types of lenses, the 8° and the 16° will be used as meeting all requirements.

3. The effect of the luminous daylight signals is to a very great extent independent of the background.

4. No reduction of visibility at twilight, whereas with the semaphore signals, neither the arms nor the lights are readily visible during this period of the day.

5. In foggy weather the daylight signals are visible within their distribution angle from greater distances than the semaphore signals.

6. No reduction of visibility due to snow and ice.

7. No material reduction in visibility owing to the suspension structures for overhead lines.

8. Visibility from a train at rest close to the signal is satisfactory for signal heights up to 40 m. (33 feet) in spite of the reduced depth dispersion. This is due to the fact that the hemispherical lens stands out considerably beyond its mounting and the back plate of the signal.

Certain advantages arise from the fact that the signal is invisible beyond its cone of light. On straight sections it has frequently been disastrously evident at night, that the driver has sighted in addition to his proper signal the next one following it, and under unfavourable circumstances the latter has appeared to him to be the first one. With the daylight signals the cone of light of the more distant of the two signals has under suitable circumstances been depressed with reference to the section, so that the latter light only enters the driver's field of view after he has passed the nearer signal.

An important point in working out the electrical connections for the daylight signals which should be given consideration is the question of reducing the luminous intensity at night. On the Reichsbahn it is a requirement that at night the permanent way men's signals, for instance "go-slow" signals at places where construction work is being carried on, etc., and the train tail lights should not show too dimly as compared with the daylight signals.

From observations made on the trial section in Silesia the contemplated reduction of pressure at night from 12 volts to 7 volts was found to be insufficient. In clear weather these signals at night appeared awe inspiring and enormous and the above-mentioned permanent way men's signals, etc., burning paraffin became almost invisible. It was not until the night pressure was reduced to 5 volts that the brightness ratio between the daylight signals and the other signals was reduced to reasonable proportions.

#### 4. — *Height of signals.*

A question that has not yet been definitely settled, is the ruling regarding the heights for light signals. In the case of semaphore signals in Germany, in the same way as in England, considerable heights have often been given signals in order to have the sky as the background. As, however, the effect of the daylight signals is if anything better with a dark background than with a light background, it was thought at first that signals of no great height, that is about 4 m. (13 feet) should be installed throughout. The fact however was overlooked that there may be other reasons for choosing a greater height; these are:

1. Obstructions to the view due to embankments, buildings, bridges, etc.
2. Obstructions to the view due to trains on adjacent tracks.
3. Danger of confusing signals when these are in groups and are approached from a curve. In such cases it is desirable to bring the whole group of signals into view at the earliest possible moment which can frequently only be achieved by increasing their height.

It might be possible to help matters

by installing special repeater signals between the home and distant signals. Such a solution is however undesirable on account of increased cost and multiplication of signals; in specially difficult cases it may be unavoidable to employ this method.

As in the new type of light signals, a height of 10 m. (33 feet) up to the upper-

most light is permissible and in addition still greater heights may be introduced without harmful effect by placing two lanterns close under one another but with the centres of the beams suitably inclined, there is no obstacle to the adoption of considerable signal heights in connection with light signals when special conditions have to be met.

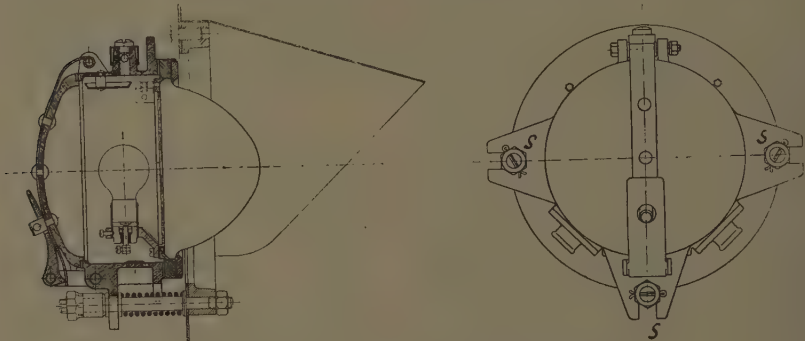


Fig. 21. — Longitudinal section and back view of the new Siemens & Halske daylight signal lamp.

### 3. — *The question of back lights.*

The lack of a back light has frequently been brought forward in print as a defect in the usual daylight signals as opposed to the ordinary semaphore types.

The opinion is held in many quarters that the back lights are only of importance to those of the staff who are more or less stationary in the neighbourhood of the signal. But on the trial section in Silesia it appeared that under certain circumstances the back light is a necessity for the staff who are actually on the train. The increase in the lengths of goods trains made possible by the introduction of more powerful locomotives could not be followed up in Germany at

many places by a corresponding increase in the length of the loops at passing places. On this account it became necessary when goods trains were held up to allow other traffic to pass, to split the goods train up and to run a portion of the train into a siding. When the goods train is made up again it may sometimes happen that the locomotive is a long way beyond the starting signal, so that the driver has to look back to observe his signal. On this account it is necessary to instal at the back of the disc of the daylight signal a second similar signal which is only lit up when the signal proper was at « line clear ». This secondary signal took the form of a oblique bar of light showing through clear colourless glass.

## 6. — *Sensitivity to external influences.*

The daylight signals are affected by, in the first place, displacement of the filament of the lamp away from the focal centre and secondly by displacement of the axis of the cone of light. The arrangement which held formerly, under which the maintenance staff were able to adjust the position of the lamp bulb in relation to the lens, was not found satisfactory. In the newer types of signals the lens with its mounting and the lamp with its socket are made integral. This arrangement guarantees that when the bulb is put in, the filament will be situated exactly at the focal point without any special adjustment (fig. 24).

As regards the proper adjustment of the cone of light according to the section of line, it has not been found possible to do without the services of the maintenance staff. The lantern is therefore secured to the disc by means of three adjusting screws (fig. 24). Changes in the cone of light may be produced by wind pressure, hence especially with high signals a substantial design of the signal pole is called for. In addition such changes may take place as a result of settlement of the permanent way. It is therefore necessary carefully to watch such signals as are situated on newly made embankments.

If it is considered that visual observation is not sufficiently reliable in such cases, it may be considered desirable, in order to make for greater security at least at night, to replace the special lens lantern by an ordinary electrically lighted signal lamp having the usual wide dispersion. In daylight the failure of the daylight signal light is less dangerous because the driver is able to see the back plate at a sufficient distance away and

because if there is no light from it, it means that he must stop at the signals.

## 7. — *Reliability of daylight signals as compared with semaphore signals.*

The consideration referred to in the last paragraph of the previous section leads naturally to the question as to the reliability of daylight signals as compared with that of the semaphore signals. Two points of view have to be considered :

1. Reliability against the unintentional giving of a line clear signal;

2. Reliability against the absence of the signal or of a part of its aspect.

As regards point 1, there is no doubt that the daylight signals give a greater degree of reliability than mechanically or power-operated semaphore signals. These latter may, in spite of all preventive measures, occasionally remain wedged in the "line clear" position owing to formation of ice or to other external influences. This cannot happen with daylight signals without movable spectacles, as installed on the Reichsbahn, as there are no moving outside parts and the operation of the signals is effected exclusively by switching in the signal box.

As regards the second point (absence of the signal, etc.) the semaphore signal is almost absolutely reliable in daylight. The semaphore signal cannot be made to disappear, at the worst it can only be removed by using force or ill will. With the daylight signal there is the possibility of the lamp failing; the degree of probability of such an occurrence depends on the current supply and on the wiring. As however the back plate of the signal still remains as a warning when the lamp is extinguished in the

daytime the danger due to extinction of the light signal during the hours of daylight need not be considered of any importance.

On the question of reliability of signals during the hours of darkness a distinction has to be made between semaphore signals lit by paraffin lamps and those lit electrically; as compared with the paraffin lamp signal the daylight signals are distinctly superior provided the circuits are suitably arranged. Whereas the failure of the paraffin lamp may be unnoticed, the daylight signals on the Reichsbahn are provided with pilot lights in the signal boxes and by means of these the condition of the signal lamps can be observed by the signalman. In addition to this, every red lamp on the signal back plate is installed in duplicate; only one lamp is lighted at a time. As soon as this lamp fails a relay in the signal box comes into operation and automatically switches on the second red lamp (see fig. 22). When a green light fails, a red light appears at the home signal and a double yellow light on the distant signal. This is done in order that the driver shall not have to search for an unlighted signal back plate in the dark.

In the same way very full protection is provided by means of relays against the appearance of incomplete signals. Provision is more especially made to obviate the danger which unavoidably exists in systems where paraffin signal lamps are used, such as the case of a train being directed on to a branch line and the failure of a green light causing a "line clear" signal for the through track to appear.

With electrically illuminated semaphore signals the same protective arrangements are in use in Germany as for the daylight signals. There is, however,

a difference between these two types of signal in the event of a failure of current supply of some duration. With the electrically lighted semaphore signals the service can be quickly reinstated by means of emergency paraffin lamps. With the daylight signals, on the other hand, it is only possible by means of emergency lamps to indicate a permanent stop or warning signal because of the absence of a movable spectacle. This will, however, be of little use for operating the traffic, because all trains would then come to a stop before all signals affected by the failure of current. For this reason the requirements as regards stand-by sources of current supply are much stricter in Germany for the daylight signals than with the ordinary electrically illuminated signals, for which latter in general one stand-by source of current supply is considered sufficient.

With an adequate current reserve available the daylight signal is much more reliable at night than the semaphore signal with paraffin lamp and is equal to the semaphore signal with electric lighting.

### 8. — *Current supply.*

The current supply for the daylight signals on the trial sections in Silesia is provided in the following manner:

The overhead line for the operation of the electric trains, which carries single-phase current of 16-2/3 periods and 15 000 volts, provides the main source of current supply. Pole transformers are used for supplying current to the signals (fig. 23). Four such transformers are supplied for each railway station, and these transformers are connected to different, separable, sections of the overhead line. Each signal box can switch on to each of the four transformers

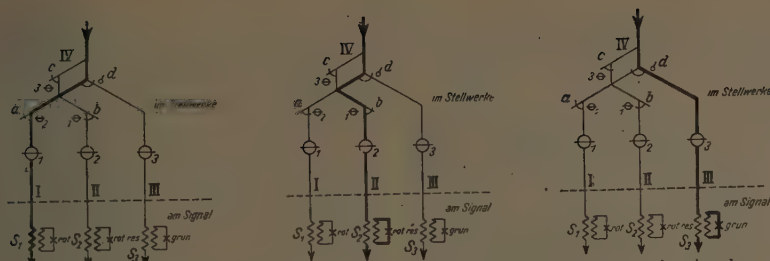


Fig. 22. — Theoretical wiring diagram of the circuits of a one-arm main signal.

Explanation of German terms: Am Signal = At the signal. — Im Stellwerk = In signal cabin.



Fig. 23. — Transformers mounted on poles.

so that in case of interruptions of the supply or of maintenance work being done at particular points of the overhead line the signalling current can always

be maintained by switching over to another pole transformer.

In spite of this fourfold protection the current may fail, in case of failure at

the main generating station or of the transmission line between the main generating station and the sub-station.

To meet such cases each railway station has a stand-by connection to the local public electric supply network. Further, at each railway station and at every block post a small petrol driven generating set is provided. The importance of such stand-by arrangements was shown in the Winter of 1928-1929 when the transmission line was interrupted by snow. While repairs were being effected traffic was maintained by steam-driven locomotives. The signals were lighted by means of the afore-mentioned stand-by sources of current supply.

The pole transformers supply at the secondary winding current at 220 volts during daylight; at night a suitably reduced voltage is obtained and led to the signal by way of the contacters and relays in the signal boxes. At every signal there is installed a so-called « signal transformer » which further reduces the voltage to 12 volts for the lamps.

#### 9. — *Economy.*

The current consumption of the light signals in Silesia amounts to approximately 1.7 kw.-h. per signal per 24 hours. The question of cost of current had hitherto hardly been considered, because the additional load due to the signals which were supplied from the traction network was comparatively small. For this reason the two methods of economizing current adopted by other railways, namely, the lighting of the signals by an intermittent current and the automatic closing of the signal circuit by the trains, were not adopted. Moreover it was feared that such methods would reduce the reliability of the signals as a

failure of the necessary auxiliary apparatus would tend to make for uncertainty.

The first cost of the light signals in Silesia was comparatively high, due in the first instance to the fact that this was a first installation for which designs and patterns were not available. This trial installation does not therefore serve as a criterion for the probable cost of similar installations which may be made at a later date. Similarly no definite data are available as regards cost of maintenance; it can however be seen that these will be less than with the semaphore signals.

#### 10. — *Trial section for comparison.*

Mention was made at the beginning of this chapter of a further trial section on the line from Berlin to Lichterfelde, where on account of the shorter braking distances of the trains the requirements of the luminous daylight signals were less stringent. On this section the old type of daylight signals with stepped lenses were found to be fully satisfactory, so that it was not necessary later on to replace them by the hemispherical lenses.

#### B. — *Daylight signals on the Berlin Metropolitan Railway (overhead lines).*

The change over to electrical operation of the Berlin Metropolitan Railway (overhead lines), which took place in 1927 and 1928, gave the opportunity for a third installation on a larger scale of daylight signals. Although here too the braking distances were short (about 150 metres = 492 feet), the conditions on account of the curves were almost more unfavourable than on the trial section in Silesia. For this reason the hemispherical lenses shown in figure 19 were adopted right from the start on the Berlin Metropolitan. The result was

excellent. The lateral distribution was entirely adequate at all points. The daylight signals of the Metropolitan have been in operation since June 1928 and have given complete satisfaction.

The superiority of the daylight signals over the former semaphore signals is particularly noticeable on this line, because at many points where the line passes through blocks of houses the background is very unfavourable for semaphore signals.

The aspects shown on the Berlin Metropolitan differ from the usual practice of the Reichsbahn inasmuch as for the first time signals having three aspects or indications in the American style have been adopted. The arrangement of signals on the Metropolitan is indicated in the following schedule :

<i>Signal indication.</i>	<i>Meaning for the driver</i>
Green + green.	<i>Line clear.</i> Line clear may be expected at the following signal.
Green + yellow.	<i>Line clear.</i> Be prepared to find next signal at stop.
Yellow + yellow.	<i>Stop.</i> Then proceed cautiously to enter the next block section without awaiting special instructions.
Red.	<i>Stop.</i> Do not proceed without special instructions from the station.

The employment of two different forms of « Stop » indications was necessitated by the introduction, at the same time, of the automatic block system.

The indications of the double light

signals are grouped according to the following easily understood rules :

Reading from left to right, the first light indicates the condition of the first section following the signal, the second light refers to the probable condition of the section next to the former. Green indicates « Section clear », yellow means « section occupied ».

This type of signal, giving three indications, enables rapid and safe operation of trains, as generally speaking they give the staff on the train an indication of the condition of two block sections ahead. The initial outlay and maintenance costs of the signalling installation on the Metropolitan Railway are dealt with in Chapter III wherein automatic block signalling is considered.

#### C. — Extension of the application of daylight signals.

The favourable results obtained with daylight signals on the three above-mentioned lines have brought up the question of a further extension of this system to steam operated lines. Among the advantages already mentioned the two following are considered the most important:

1. The fact that daylight signals are not affected by the type of background;
2. The high efficiency of these signals during the twilight periods, an efficiency which cannot be attained by the ordinary semaphore signals.

However desirable under these circumstances, a more general introduction of the daylight signals would appear, it must be remembered that the replacement of existing types of signals by the new system will in many places meet with difficulties in providing suitable supplies

of main and stand-by current. The use of primary batteries would not be considered in view of the attitude which it has been decided to adopt in regard to certain current saving devices (intermittent supply and automatic switching in of the supply by the train).

In the first instance it is intended, in addition to further installations on electrically operated lines, to provide this type of signalling on a four-track section now being built for express traffic in the Ruhr district, where suitable supplies of current are available and where the existing signals will in any event have to be changed. In addition individual (home) semaphore signals will be replaced by daylight signals in places where visibility conditions are particularly unfavourable; in such cases the corresponding distant signal will likewise be converted in order to prepare the driver for the appearance of a different type of signal.

### CHAPTER III.

#### Automatic block system.

##### A. — The installation on the Berlin Metropolitan Railway.

The automatic block system is in use on two electrically-operated lines of the Reichsbahn; these are the Berlin-Lichterfelde and the Berlin Metropolitan lines mentioned in the preceding chapter of this paper. The installation on the Berlin Metropolitan is the more modern and the more extensive of the two. The length of this line is 11.2 km. (7 miles), the number of automatically operated signals 112, and there are therefore ten signals per km. (16 per mile).

##### 1. — *Reasons for the introduction of the new system.*

The reason for the introduction of automatic block signalling, which was carried out concurrently with the electrification of the City Railway, was the desire to increase the traffic density up to a train interval of 1 1/2 minutes. Under such dense traffic conditions it was necessary to cut out every avoidable source of delay, hence above all things to reduce the time required to operate the signals and block system.

##### 2. — *General technical details of the arrangement.*

The signals employed were the daylight signals with double lights, already described above (fig. 24).



Fig. 24. — Automatic block signal on the Berlin Metropolitan Railway.

The basic principle of the automatic block system on the Berlin Metropolitan is the same as in most similar installa-

## Stromkreis

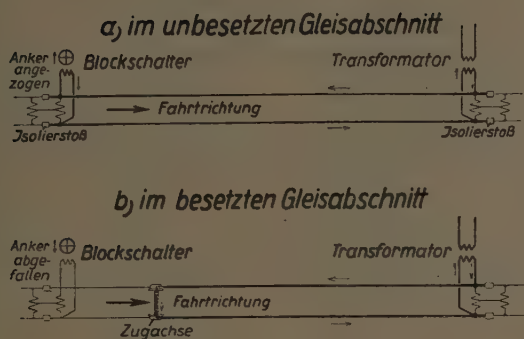


Fig. 25. — Track circuit.

Explanation of German terms: Anker abgefallen = Armature released. - Anker angezogen = Armature attracted. - Block schalter = Block relay. - a) Im unbesetzten Gleisabschnitt = a) In unoccupied track section. - b) Im besetzten Gleisabschnitt = b) In occupied track section. - Stromkreis = Circuit. - Zugachse = Train axle.

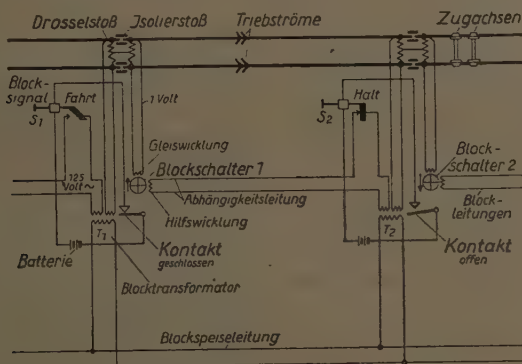


Fig. 26. — Wiring diagram of two signals.

Explanation of German terms: Abhängigkeitsleitung = Proving circuit wire. - Batterie = Battery. - Block leitungen = Block wire. - Blocksignal = Block signal. - Blockschalter = Block relay. - Blockspeisung = Block feeder. - Blocktransformator = Block transformer. - Drosselstoß = Reactance joint. - Fahrt = Line clear. - Gleiswicklung = Track winding. - Hilfswicklung = Auxiliary winding. - Kontakt offen = Contact open. - Kontakt geschlossen = Contact closed. - Triebströme = Traction currents. - Zugachsen = Train axes.

tions in other countries. A block relay operates the signal; this relay is energized by alternating current through the

track circuit which extends the whole length of the block section. As soon as the train enters the section the track cir-

circuit is short circuited; the relay is de-energized and thus causes the signal to take up the danger position (see fig. 25). This well-known arrangement was supplemented by a special safety device, which checks the operation of the stop signal in the rear of the train which it is designed to protect. For this purpose a proving circuit is provided on a separate line. The phases of this circuit are out of step with respect to the track current. The relay is worked as a 2-phase relay and designed so that the armature can only be attracted when both phases of the current are available, whereas a single phase suffices to hold it in position. The first phase is supplied by the track circuit current, the second from the proving circuit (fig. 26).

A block signal can therefore only be moved out of the stop position to line clear, if:

1. The track circuit is not short circuited by a train and
2. The following signal is in the stop position.

If the signal in question takes up the line clear position under these circumstances the conditions remain unaltered, even if the following signal moves to line clear and thus opens the proving circuit.

The method of protection described above is considered to be a very important feature of automatic signalling and an indispensable condition for the introduction of the latter, for the most perfectly designed relay may fail once in a while, and in that event the proving circuit warns the train.

As a protection against the overrunning of stop signals automatic train stops are provided on the Metropolitan at the place where the signals are erected; these train

stops operate the air brake on the train when the corresponding signal is at stop. A detailed description of this apparatus is not within the scope of the points under discussion. The application of the automatic train stop requires to be mentioned here because it affects the arrangement of the signalling installation. In order to prevent a train, in consequence



Fig. 27. — Protection section (overlap).

Explanation of German terms: Streckenabschnitt = Section of line. — Gleisabschnitt = Section of track. — Schutzstrecke = Overlap.

of inattention on the part of the driver, passing a stop signal at full speed and colliding with the train in front, a length of section behind the signal equal to the braking distance of the train must be kept clear when a train is approaching. For this purpose the well-known method of overlap is resorted to, staggering the insulating rail sections with respect to the block sections which are limited by the signals (fig. 27). At all signals with the exception of the starting signals at stations, the length of overlap is equal to the distance required to stop the train when running at the maximum speed of 50 km. (31 miles) per hour. In connection with the introduction of the automatic block system on the Metropolitan Railway, permission had to be given for trains to pass signals standing at danger in unoccupied sections without special permission from the signalling staff. When this happened the automatic train stop mentioned above had to be put out of action by means of a special device on the train, but this was only possible

after the train had been brought to a stand-still and necessitated a stop lasting a few seconds. A longer wait is not imposed on the Metropolitan Railway, contrary to the practice on other lines, the object being to obstruct as little as possible the continuous flow of traffic; in order however to prevent accidents the orders are that the next two block sections shall be passed through at a speed not exceeding 15 km. (9.3 miles) per hour. Under these circumstances the following state of affairs might arise and

might lead to a misunderstanding on the part of the train staff :

Should a train come to rest in the overlap behind signals  $S_2$  (fig. 27) as can easily occur owing to the closing up of the trains due to hold-ups, then the signal behind that train remains at line clear. The signal in the rear  $S_2$  is at stop. If now a second train, after rendering the train stop inoperative, should move into the block section  $S_2$  to  $S_3$ , the driver will find the next signal in front of him at line clear. This might mislead



Fig. 28. — Subdivision of the insulated track sections.

him and allow him to proceed at full speed again.

For this reason the following supplementary arrangement was afterwards introduced (fig. 28) :

The insulated rail sections are subdivided by means of a treadle rail contact situated opposite the signals; they are thus divided into a block section  $a$  commencing at the signal, which is identical with the overlap, and a clearing section  $b$ . As soon as the first axle of a train enters the block section  $a$ , the signal  $S_2$  moves into the stop position. When the last axle of the train arrives at the clearing section  $b$ , the block signal  $S_1$  in the rear moves to line clear.

### 3. — Division of the line in block sections.

The division of the line in block sections was in the first instance determined by the requirement, that under or-

dinary conditions of running, a train as soon as it approaches a signal, should have at least two unoccupied sections in front of it. If this were not the case the train would be warned by the green-yellow signal indication given by the next signal (see Chapter II-B), and would have to reduce speed. Such reductions in speed should however not take place under ordinary running conditions. Moreover, the regular appearance of warning signals would weaken their effect on the drivers or might become entirely neglected. From this consideration the following rule has been laid down :

For the correct running sequence of two trains the minimum interval between the head of the second train and the head of the first train shall be as follows (see fig. 29) :

1. A short sighting distance of at least 20 m. (66 feet) between the second train and the main signal (this distance to

be increased if the block section is less than the braking distance);

2. Two block sections;
3. The braking distance;
4. The length of the train.

This interval *Z* made up as above may at the most have a length which can be covered in 90 seconds (the scheduled smallest time interval between trains).

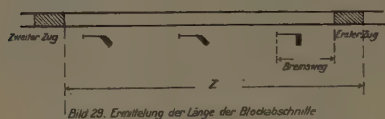


Fig. 29. — Determination of the length of the block sections.

Explanation of German terms: Bremsweg = Braking distance. — Erster Zug = First train. — Zweiter Zug = Second train.

This rule results in very short block sections in front of the stations because the platform stops (up to 30 seconds), together with the time lost in braking and starting are all included in the time allowed for covering the section *Z* and these time losses can only be compensated by shortening the block sections. Accordingly, in front of most of the stations on the Metropolitan Railway there are two short block sections each having a length of 90 metres (295 feet). The home signal which protects the station itself is placed right up against the end of the platform. As is well known, with such an arrangement of signals with short block sections in the rear of the station it is possible for the second train to be moving up close to the station while the first train is moving out of it.

#### 4. — Supply of current.

For the automatic block system working and for lighting the signals the current in the case of the Berlin Metropolitan Railway is obtained from the

same source as the traction current. Whereas however the current for operating the trains is continuous, the supply for the block sections and signals is transformed to alternating current at 50 periods.

#### 5. — Economic results.

The installation of signals described above has worked satisfactorily throughout since it was placed into service on the 1 June 1928. Wrong signal indications have not appeared and interruptions were rare. The economic results are particularly notable. The initial cost, excluding the automatic train stops, but including the daylight signals, the signal gantries and the arrangements for supplying current amounted for 112 signals to 2 000 000 Rm. The annual saving in personnel on the signalling staff amounts to 120 000 Rm., that is about 6 % of the total cost. No increase of the maintenance staff was called for.

If automatic signalling had not been introduced, new electric lock and block arrangements would have been necessary in consequence of the increased density of traffic and the total cost would have been the same as above. But the staff both for operating and maintaining the system would have had to be increased in accordance with the increase in the number of blocks. We therefore have set an increase in the operating cost with non-automatic block working against a saving in working costs with the automatic system.

#### B. — Prospects for the further application of the automatic block system in Germany.

With the Metropolitan Railway we are dealing with electrical train operation for a special purpose and at comparatively

low speed. On the standard steam operated high speed lines the conditions on the Reichsbahn are much less favourable to the introduction of automatic block signals than was the case under the special circumstances of the Metropolitan Railway. A large percentage of steam lines of the Reichsbahn are laid on steel sleepers, and steel sleepers are still, in the present state of our technical development in this direction, an obstacle to the application of rail-borne currents and hence to the introduction of automatic block signalling on the usual system.

It is true that in Germany the principles of using only timber sleepers on important express lines has been adopted. Thus the most serious obstacle to the use of automatic signals is removed, but there is still a further difficulty.

As is well known, with the automatic block system, the driver has to be allowed to pass a stop signal without having obtained special permission from a signalling station; the staff on the train is, as a rule, ignorant of the condition of the section ahead of the signals, when this necessity arises. It is therefore necessary for them to proceed with the greatest caution. Observation of the sections, especially on curves, is rendered extremely difficult owing to the size of the boiler on the modern locomotive. In addition operation of the trains would be delayed owing to the necessity of proceeding with caution.

With the goods train there is the additional consideration that even at low speeds the distance required to bring the train to a stop is relatively long. It would appear that on standard steam operated lines it would be necessary to specify that every second block post be manned so that, when signal failures take place, the trains

follow one another at the distances between two guarded block stations worked by telegraph signalling, in which case the driver would not have to run in such a way as to be able to stop within range of vision. The economic value of automatic signalling would be considerably restricted under these conditions. Nevertheless in suitable cases the interpolation of



Fig. 30. — Tail light detector.

automatic block signals between ordinary manual block posts will be kept in view for the future.

An ingenious invention by Hampke in Altona is worth mentioning in this connection. The object of the invention is to make automatic signalling possible even with steel sleepers by adopting the so-called « point » or intermittent system. The question which has hitherto been unsolved in connection with the intermittent system, that is with an arrangement of automatic signals without the use of rail circuits was, as is well known, the question how to indicate automatically, whether a train with all its axles (complete) has passed out of the block section, and how it would be possible

to arrange matters so that the section is not cleared if, owing to failure of the couplings, a portion of the train still remains in the section. Hampke's invention has solved this problem by an arrangement which makes it possible to observe the passage of the tail end of the train past a fixed point. The inventor calls it « the tail light detector » (fig. 30). This apparatus contains a lamp bulb which throws an intense concentrated ray of light on to the train, and a selenium cell which forms part of the circuit of a line relay.

A special mirror is fitted to the red tail light of the train, which mirror is similar to the one used by the inventor Bäseler with his well-known optical signalling apparatus. As soon as the end of the train passes the selenium cell detector, the mirror directs the ray of light back into the selenium cell and renders it conducting, so that the circuit through the relay is closed. An essential point in Hampke's idea consists in the arrangement that the lamp bulb is only switched in at the approach of the train and, after the train has passed, it is automatically switched out again. This enables one to make use of a primary battery to supply current for the lamp. If the arrangement of switching on the light at the approach of a train should fail no danger would arise, but an interruption in the traffic would take place. An installation of the invention under ordinary working conditions has been in operation for some time on the suburban line Blankenese-Wedel near Hamburg and has given good service.

## CHAPTER IV.

### Conclusions.

Looked at from the point of view of German experiences the conclusions arrived at by the Congress of 1923 would have to be extended somewhat as follows :

1. At points where there is no junction, two signal indications at home and distant signals suffice; where there are junctions on high speed sections at least three indications for each signal are desirable. If, however, a further signal follows at a short distance from the home signal, it is desirable in addition to indicate the position of such following signal and this can be done by adding a special distant signal applying to it.

2. In addition to the semaphore type the disc type of signal comes into consideration for distant signals placed at a low level.

3. Where confusion between yellow and red is to be apprehended, it is recommended to use two yellow lights.

4. Daylight signals have the advantage over semaphore signals that visibility is unaffected by poor background or in twilight; they require good lateral dispersion on curves and a specially reliable supply of current.

5. The application of automatic block signalling is so far limited to lines laid on wooden sleepers. The automatic system is particularly suitable for such lines where no danger is to be apprehended from passing the stop signal without special permission from a signal cabin.

## REPORT No. 3

(All countries except America, the British Empire, Germany, Holland and colonies, China, Japan, Belgium, France, Italy, Portugal, Spain and their colonies)

ON THE QUESTION OF RECENT IMPROVEMENTS IN PERMANENT WAY TOOLS AND IN THE SCIENTIFIC ORGANISATION OF MAINTENANCE WORK (SUBJECT IV FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) <sup>(1)</sup>,

By J. HAUER,

Engineer, Ministerial Councillor and Head of the Department iv/3 at the Czechoslovakian Ministry of Railways.

Figs. 1 to 8, pp. 1033 to 1042.

### INTRODUCTION.

The part allotted to the reporter consists in drawing up a complete reply to Question IV in accordance with the detailed questionnaire which was sent to the administrations mentioned below, and in giving a summary of each of the replies that he has received.

As will be seen from the list of the administrations, the total length of railways which they control is 84 773 kilometres (52 676 miles).

Replies to the questionnaire have only been received from the railway administrations shown separately, which own or operate a total of 60 973 km. (37 887 miles) of lines, forming 72 % of the total length of all the lines within the purview of the questionnaire.

It is unfortunate that it is impossible to compile the reply to the question in the way it should be done, that is to say on the basis of the replies from the whole of the administrations consulted. Still, the replies received contain sufficient

information to enable an opinion to be formed and a complete reply to be given to question IV :

In view of the matter and the form of the replies furnished for each of the questions asked, and particularly for those questions which have been divided into several parts, it has been considered necessary in drawing up the report, for the sake of greater clearness and to avoid prolixity, to depart from the exact order of the questions and of each of the parts of the sub-divided questions.

### LIST OF QUESTIONS.

#### FIRST PART.

#### Recent improvements in permanent way tools.

QUESTION I. — *Have you introduced or improved in recent years mechanical appliances for permanent way maintenance, and if so, how long have you adopted them?*

---

(1) Translated from the French.

Do you employ mechanical appliances for the following operations :

a) Bottoming of the bed on which the track is to be;

b) Loading, transporting and unloading ballast;

c) Loading and unloading rails and sleepers;

d) Laying and packing the ballast;

e) Unloading and laying completely assembled lengths of track;

f) Transport of materials along the track;

g) Drilling and adzing sleepers;

h) Putting sleepers into position;

i) Laying rails;

j) Fixing coach screws, chairs or sole-plates on to the sleepers;

k) Tightening the bolts at the joints or other portions of the track;

l) Shaping the ballast;

m) Straightening, levelling and packing the track;

n) Weeding and cleaning the ballast, either over its entire width or merely outside the sleepers;

o) Straightening, cutting and drilling rails;

p) Do you employ special vehicles for transporting materials?

q) For any other purpose?

List of the Administrations to which the detailed questionnaire relating to Question IV was sent.

Country.	Name of the Administration.	Kilo- metres.	Miles.	Reply.	
				Not received.	Received.
Bulgaria . . .	State Railways . . . . .	2 285	1 420	...	1
Denmark . . .	State Railways . . . . .	2 517	1 564	...	1
	Aalborg Private Railway . . . . .	259	161	1	...
	East Seeland Railway . . . . .	47	29	1	...
	South Fionian Railway . . . . .	216	134	1	...
	Lolland-Falster Railway . . . . .	104	65	1	...
Egypt . . . .	State Railways . . . . .	3 305	2 054	...	1
Finland . . .	State Railways . . . . .	4 815	2 992	...	1
Greece . . . .	State Railways . . . . .	1 320	820	1	...
	North-East of Greece Railways . . . . .	74	47	...	1
	Pirea-Athens-Peloponnesus Railways . . . . .	750	466	1	...
	Thessalian Railways . . . . .	233	145	1	...
Luxemburg . .	Guillaume-Luxemburg Railways . . . . .	207	129	...	1
	Prince Henry Railways and Mines . . . . .	250	155	...	1
Norway . . .	State Railways . . . . .	3 467	2 154	...	1
Poland . . .	State Railways . . . . .	17 241	10 713	1	...
Rumania . . .	State Railways . . . . .	11 616	7 218	...	1

Country.	Name of the Administration.	Kilo- metres.	Miles.	Reply.	
				Not received.	Received.
Yugoslavia . .	State Railways . . . . .	9 024	5 607	...	1
Sweden . . . .	State Railways . . . . .	6 461	4 014	...	1
	Bergslagen Railway . . . . .	552	343	1	...
	Blekinge-Kustbanor Railway . . . . .	203	126	1	...
	Gefle-Dala Railway . . . . .	293	182	1	...
	Göteborg-Boras Railway . . . . .	261	162	...	1
	Halmstad-Nässjö Railway . . . . .	411	255	1	...
	Helsingborg-Hessleholm Railway . . . . .	122	76	1	...
	Kalmar-Nya Railway . . . . .	195	121	1	...
	Karlstad-Munkfors, etc., Railway . . . . .	171	106	1	...
	Nässjö-Oskarshamn Railway . . . . .	148	92	1	...
	Nora-Bergslagen Railway . . . . .	173	108	...	1
	Nora-Ostergötland Railway . . . . .	134	83	1	...
	Norholm-Westervik-Hultsfred Railway . . . . .	245	152	1	...
	Östra-Skånes Railway . . . . .	206	128	1	...
	Oxelösund-Flen-Västmanland Railway . . . . .	300	186	1	...
Switzerland . .	Stockholm-Roslag Railway . . . . .	238	148	...	1
	Stockholm-Vesternas-Bergslagen Railway . . . . .	479	298	1	...
	Uddevalla-Venersborg-Herrljunga Railway . . . . .	92	57	1	...
	Västergötland-Göteborg Railway . . . . .	380	236	...	1
	Federal Railways . . . . .	2 942	1 828	...	1
	Bernese Alps Railways . . . . .	253	157	...	1
	Birsig Town Railway . . . . .	17	10.6	1	...
Czechoslovakia .	Rhætian Railway . . . . .	276	173	...	1
	Viège to Zermatt Railway . . . . .	35	21.7	1	...
	Yverdon to Sainte-Croix Railway . . . . .	25	15.5	1	...
	Lausanne to Ouchy Railway . . . . .	2	1 2	1	...
Total . . .		84 773	52 676	23 800 (14 789)	60 973 (37 887)

QUESTION 2. — *If such appliances are employed, please give a description of the appliances in use, explained by drawings, sketches or photographs and all details which you consider necessary to understand them perfectly.*

QUESTION 3. — *Please give the cost of*

*purchasing and installing the said appliances, and the working expenses.*

QUESTION 4. — *What saving results from the use of these appliances, taking into account wages, auxiliary appliances, grease, lubricants, interest and amortization of the cost of the appliances, etc.?*

*How many men are required to work the appliances?*

QUESTION 5. — *Please give the minimum length of track, at and above which the use of mechanical appliances would be profitable or economical.*

QUESTION 6. — *If the saving is slight, what other advantages have led to the introduction of the appliances, for example, a comparison of the time required to carry out operations by one or the other method under average or normal conditions.*

QUESTION 7. — *If such appliances are used on the track what is the source of power?*

*Can it be utilised while the track under treatment is in service?*

*Is it portable without obstructing tracks in service?*

*Over what range may the appliances be used without moving the source of power?*

The mechanisation of work on the permanent way has been introduced on some railways permanently for certain operations; other railways are as yet in the trial stage of mechanical appliances, so that manual labour predominates.

In this connection, an important part is played in the first place by the *extent of the railway system* of each of the administrations because, among other things, upon this extent mainly depends the point of knowing whether mechanical work is more rational than manual labour.

If we review the different operations to be considered according to the question set, it is necessary to mention in the first place the use of mechanical appliances in the transporting and unloading ballast by means of *special wagons for the*

*transport of ballast.* These wagons are in use on the *Danish State Railways*, the *Finnish State Railways* and the *Swiss Federal Railways*. From the description and the photographs forwarded by the Administration of the Swiss Federal Railways, the ballast wagons are so contrived that the ballast may be unloaded uninterruptedly while the ballast wagon or the entire ballast train is on the move, and that this unloading may be adjusted according to requirements, which constitutes one of the greatest advantages of this wagon as compared with wagons that only enable the ballast to be unloaded when the ballast train is at a standstill (see figs. 1 and 2).

The Swiss Federal Railways estimate that it costs 9 200 Swiss francs to convert an ordinary ballast wagon into a self-discharging ballast wagon. One man is sufficient to look after a wagon of this kind.

A more extensive mechanisation may be observed when the packing or tamping of the sleepers comes to be considered.

The *Danish State Railways*, the *Finnish State Railways*, the *Norwegian State Railways*, the *Swiss Federal Railways* and the *Czechoslovakian State Railways* employ compressed-air tampers of the German and American types.

The Swiss Federal Railways give the results of tests carried out with tampers of a German type.

The tampers tested, of known type, comprise a petrol engine mechanical unit, a pipe line and tamping hammers. The mechanical part is situated to one side of the track so that it is not necessary to remove it when a train passes.

The *Czechoslovakian State Railways* have tried on their lines a tamper of American pattern, at the same time as drilling and assembling the sleepers by

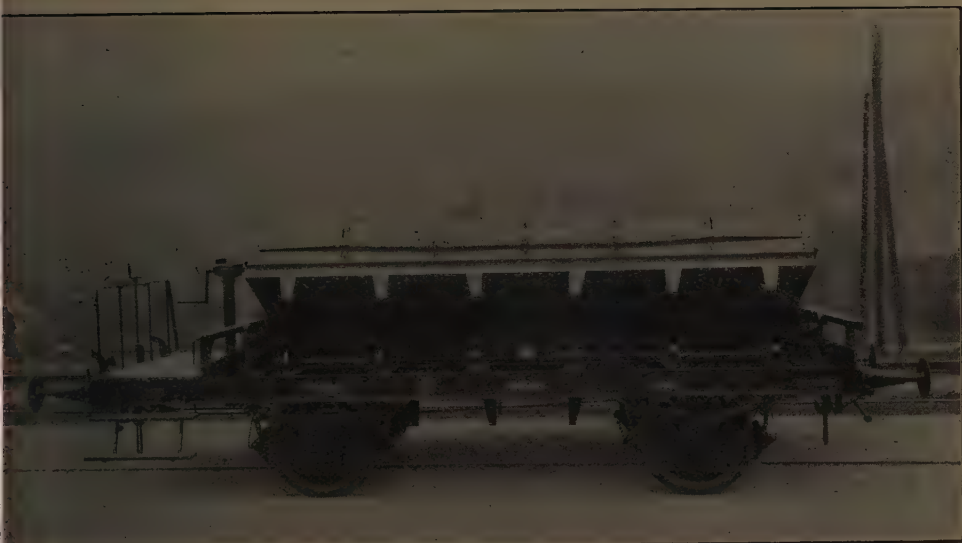


Fig. 1.



Fig. 2.

machine. The mechanical appliance consists of a portable compressor, flexible piping leading the compressed air to the

tamping hammers and also to the drills and the appliances for fixing the coach screws, driving home the rail spikes, etc.

	1st test.	2nd test.
Line . . . . .	Wyrengen-Burgdorf.	Burgdorf-Zollikofen.
Period worked . . . . .	From 5th to 22nd July, 1926.	From 12th to 31st August, 1926.
Number of tampers . . . . .	2 double tampers.	4 double tampers.
Duration of work . . . . .	15 1/4 days.	15 days.
Number of men attending to the tampers.	12	15.3
Number of days of work . . . . .	183	230
Petrol consumed . . . . .	733 l. (161 Br. gallons).	1 170 l. (257 Br. gallons).
Oil consumed . . . . .	39.3 l. (8.6 Br. gallons)	43.5 l. (9.5 Br. gallons).
Length of track tamped . . . . .	1 640 m. (1 793 yards).	2 412 m. (2 638 yards).
Cost of labour, material and depreciation; one tamper costs 4 750 Swiss francs and lasts 4 years at the rate of 250 working days per annum.	2.33 Swiss fr. per metre (2.13 fr. per yard) of track.	2.11 Swiss fr. per metre (1.93 fr. per yard) of track.

The results of tests as regards both the tamping of sleepers and the drilling of sleepers, fixing the coach screws, and driving home the rail spikes were very satisfactory, not only from the point of view of the speed and quality of the work, but also with respect to the expenses involved, if these are compared with manual labour. It should be mentioned in particular that the mechanical packing of sleepers is much more symmetrical and rational than packing by hand, because less ballast is crushed, the sleepers are not damaged by blows from picks, which frequently takes place in packing by manual labour. It is likewise very easy to pack sleepers at switches and crossings, that is to say, at those points which are inaccessible to the pick during manual work. The saving effected, as compared with manual labour, varies

between 20 and 50 %, including the depreciation of the mechanical appliances.

Mechanical appliances for adzing and particularly for drilling sleepers are very commonly used. Appliances of the most widely varying types are employed, from simple drills to machines which are located in the creosoting sheds.

One type of appliance for adzing and drilling sleepers used by the *Egyptian State Railways* is shown in figure 3.

This appliance notches and drills 2 000 sleepers daily; it costs £1 200; it costs 2 gold-centimes to notch and drill one sleeper.

The *Norwegian State Railways* use electrically driven drilling machines for sleepers. The *Czechoslovakian State Railways* have introduced an American system of compressed air drills.

The appliances for drilling the sleepers are for the most part associated with appliances for *tightening the coach screws and the rail spikes*, as in the American type of appliance just mentioned and used on the Czechoslovakian State Railways. Elsewhere, *hand appliances* are employed for tightening the coach screws as well as for fixing the *bolts*. In addition, mention should be made of special mechanical appliances for shaping the ballast bed, cleaning and weeding the ballast, appliances employed by the Swedish, Danish, Finnish and Swiss railways.

The mechanical appliances of the *Swedish* Railways, shown in figures 4 and 5, are mounted on a flat wagon, hauled by a locomotive; three or four men are required to attend to this appliance, which cleans the ballast on either side of the track, weeds and at the same time shapes the bed of ballast. When working, the appliance moves at the rate of 5 km. (3.1 miles) per hour. By means of this appliance, 30 km. (18.6 miles) of single track line may be treated daily.

Taking into account the price of this appliance, say 12 000 Swedish crowns, the cost of cleaning a kilometre of track, weeding and shaping the bed of ballast is 6 to 8 Swedish crowns (9.6 to 12.9 Swedish crown per mile).

The mechanical appliance employed on the *Swiss* Federal Railways is a track-weeding machine of the « Scheuchzer » type shown in figure 6.

The appliance, integral with the locomotive which propels it and provides it with the steam required for working it, is mounted on a two-axled wagon frame covered by a roof. It consists of a steam cylinder supplied with steam from the locomotive and driving the four essential

contrivances below, under the supervision and control of four men and a foreman :

1. A series of three vertical knives (one between the rails and the other two outside them), which being driven in between the sleepers, pull up the grass between them as the train advances at an average speed of 5 to 6 km. (3.1 to 3.7 miles) per hour. These knives are driven automatically; for this purpose, a hard steel roller mounted on a lever makes a furrow 30 cm. (1 foot) from the rail. In rising on or falling from the sleepers, it actuates a rod controlling the steam distribution slide valve, thus causing the knives to rise or fall, according as to whether they are opposite a sleeper or between two of them. All the driver has to do is to regulate the depth of penetration, and stop the knives in the raised position as soon as an obstacle appears : level crossing, wall, bridge, water pipes, etc.

2. A second mechanism operates one or two ploughs with adjustable plough shares, according as the track is double or single, which weed the ballast at the side of the track. They are lifted or lowered by means of compressed air under the control of a second driver. The forward motion itself of the vehicle causes them to plough up the sides, pull up the weeds by the roots and afterwards smooth over the loosened ballast.

3. A third mechanism, in the form of a horizontal knife, replaces the second plough on double track lines. Raised or lowered by compressed air, controlled by the third driver and pushed as the vehicle advances, it ploughs the ballast between the tracks and pulls up the weeds there.

4. Finally, steel revolving rakes, with flexible teeth and rail brushes, placed behind the wagon, level up the ballast and rake together the weeds in an effective manner.



Fig. 3.



Fig. 4.

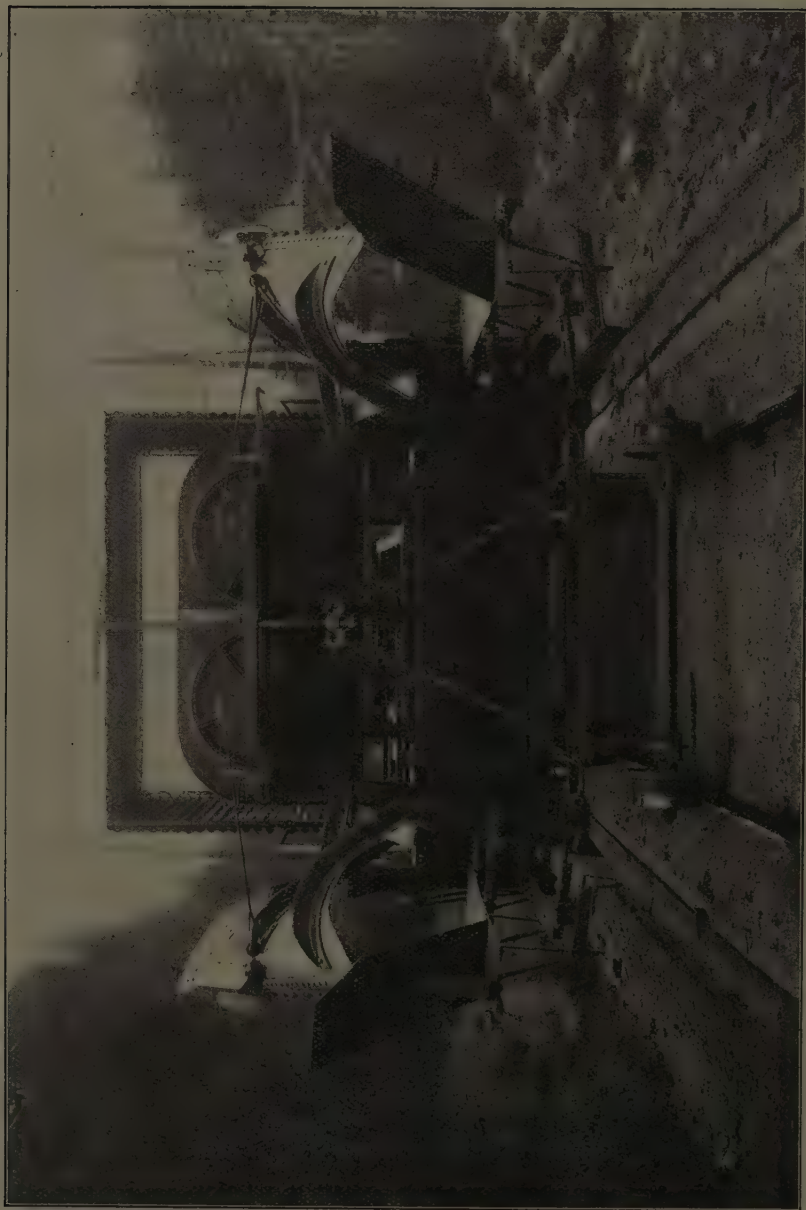


Fig. 5.

tive manner. The weeds are brought to the surface, cut up and freed from the earth attached to their roots, which almost inevitably results in their destruction.

The weeding train is completed by a service coach, including two sleeping places, a kitchen and a small dining compartment. Such equipment is indispensable for the men owing to the irregularity of the trips, which affects the meal times and owing to the difficulty of securing accomodation in many localities where the machine has to pass the night.

This mechanical appliance is the property of the Scheuchzer Company which works with this appliance by contract on the lines of the Swiss Federal Railways and of other railway companies.

According to information provided by the Swiss Federal Railways, the cost of weeding with the Scheuchzer machine is 100 to 150 Swiss francs per kilometre (160 to 240 Swiss fr. per mile), while weeding by hand would cost 200 to 350 Swiss francs (320 to 560 Swiss francs per mile).

According to the communication of the Federal Railways, the cheapest way of cleaning the track is the chemical method, which costs only 70 to 100 Swiss francs per kilometre (112 to 160 Swiss francs per mile); it should be remarked, however, that no mention is made of chemical cleaning.

For transporting rails, sleepers and small material on the line, use is made to some extent of material trains and also to some extent of small motor vehicles.

The *Czechoslovakian* State Railways have been using, since 1922, the motor trolleys shown in figures 7 and 8. These trolleys are provided with a 14-H. P. petrol engine, air or water cooled. The engine is located below the trolley, which

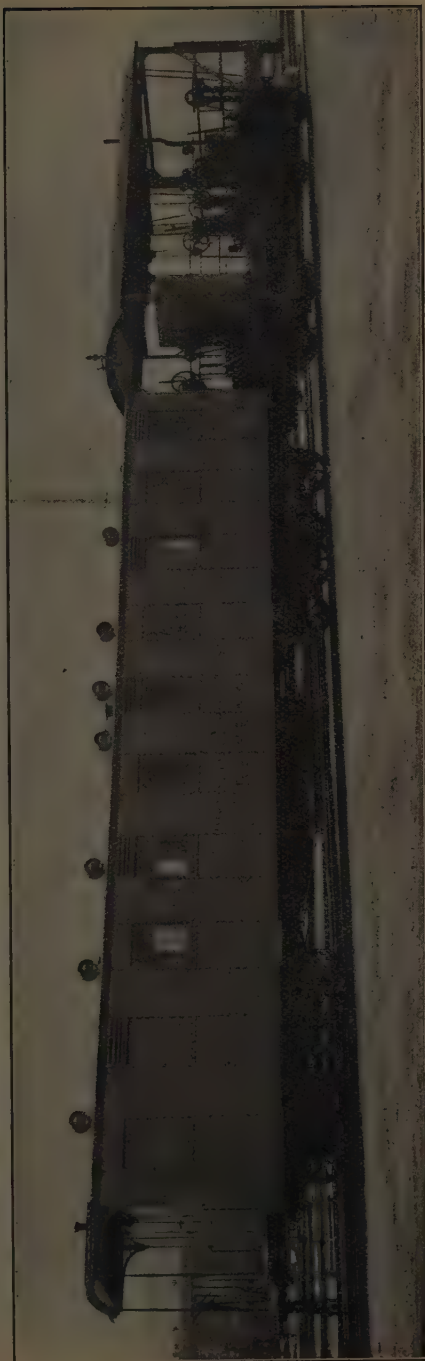


Fig. 6. — Mechanical weeder and carriage containing mess room.

is provided with a platform for the material. When rails have to be transported, the motor trolley is coupled to an ordinary trolley.

The tare of the trolley is 1 200 kgr. (2 640 lb.).

Its loading area is 2.5 m<sup>2</sup> (2.99 sq. yards).

The trolley hauls 15 000 kgr. (33 000 lb.) (with the trailer trolley).

Maximum speed : 35 km. (21.7 miles) per hour.

Apart from the large mechanical appliances for the work of permanent way maintenance, the railway administrations enumerated in the present report make use of current types of appliances such as, for example :

Rail saws;  
Special spanners for tightening screws;  
Rail levers;  
Hand drills for sleepers;  
Appliances for equalising the rails, etc.

### SUMMARY.

The replies received show that during recent years, all the Railway Administrations have been devoting special care to equipping their lines with appliances, and to suitably programming the work to be effected on the permanent way.

This is merely the result of a necessary rationalisation and cheapening of this work in connection with the economies which are necessary in the working expenses.

It is evident that the most perfect mechanical appliances from the technical standpoint are not economical when *sufficient conditions are not already present for their suitable application*. In this instance, the rule applies in particular that the rational use of any appliance or

plant intended to replace manual labour for the maintenance of the permanent way can only be realised if the working expenses, including depreciation of the purchase price, are less than the cost of carrying out the same work by hand. In addition to this calculation, the following should be borne in mind :

1. That the use of a mechanical appliance is often more advantageous than manual labour because the operation is technically more perfect, more efficient, more lasting, etc.

2. That mechanical appliances enable work which is limited as regards time to be carried out at a rate which could not ultimately be kept up by manual labour.

3. That mechanical appliances are often necessary so that they may be kept in reserve in case of a shortage of manual labour.

Taking these considerations into account, very good results have been obtained from the appliances for the mechanical packing of the sleepers, as well as the mechanical appliances for adzing and drilling sleepers, appliances which may be combined with the fixing of the sole plates on the sleepers and with the tamping of the sleepers; similarly, good results have been obtained by the use of special wagons for automatically unloading ballast and of motor trolleys for the transport of material, as well as by the use of small hand appliances.

According to our calculations, by employing the above-mentioned mechanical appliances, economies varying between 10 and 50 % of the expenses required by manual labour may be expected.

The final result of all these considerations may be formulated by the statement that the present results of the use of mechanical appliances for permanent way

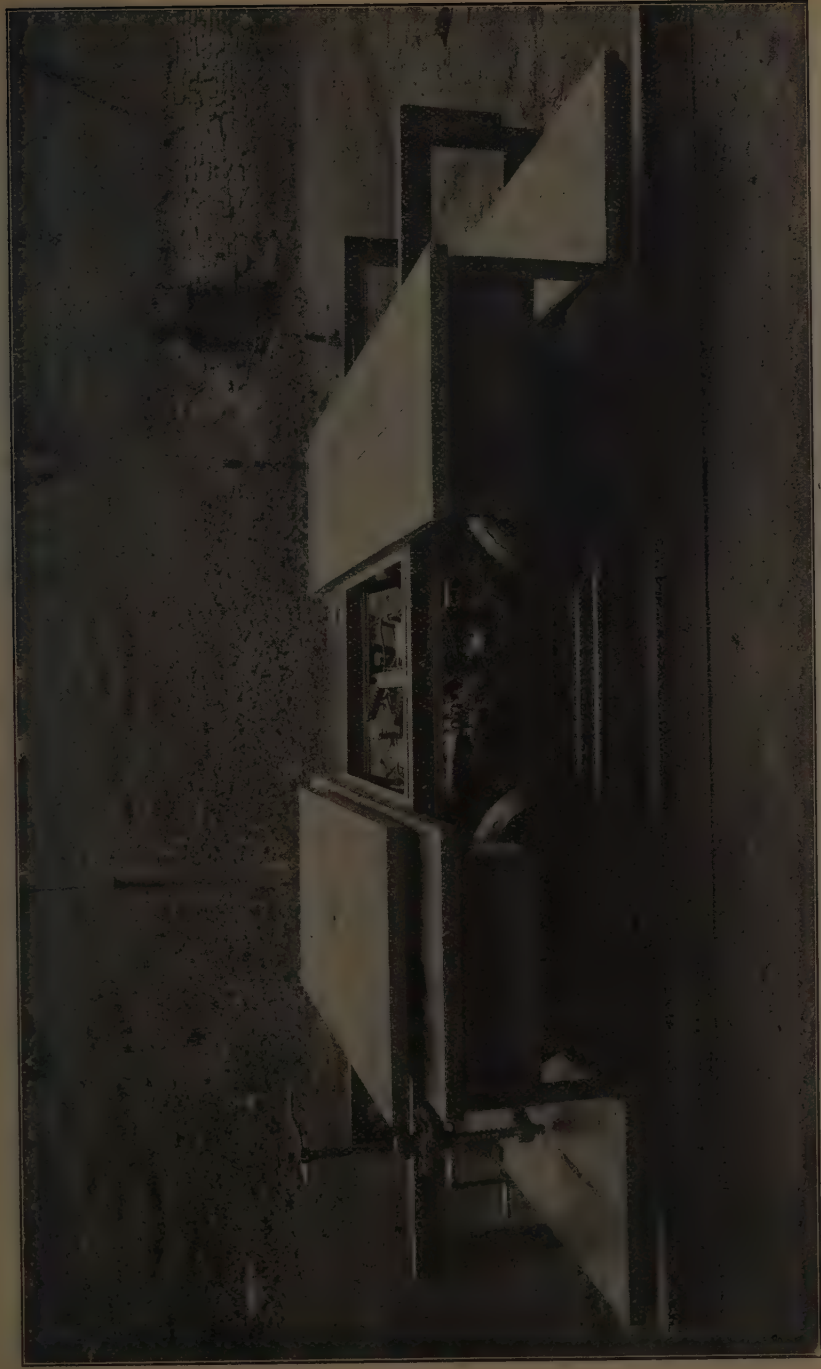


Fig. 7. — Motor trolley of the Czechoslovakian State Railways.



Fig. 8.

maintenance, and the ever-increasing need for the rationalisation of this work indisputably demand that the Railway Administrations should continue to observe *most intensely* all efforts which aim at the introduction of suitable appliances and mechanical arrangements for permanent way maintenance.

## SECOND PART.

### The scientific organisation of maintenance work.

QUESTION 1. — *What is the organisation of the permanent way maintenance on your railway?*

A. *Organisation of the maintenance personnel:*

- a) *Uniformly distributed over the lines;*
- b) *Concentrated in definitely selected places;*

c) *Personnel specially employed on the maintenance of signals, tunnels, bridges, etc.*

B. *Supervision and guarding of the permanent way:*

- a) *In special works, tunnels, bridges, etc.;*
- b) *Level crossings;*
- c) *Over the entire length of the permanent way.*

The replies received to question 1 (see Appendix I) show that the basic unit for permanent way maintenance work is, for most of the administrations, the gang, composed of a foreman and a certain number of workmen, appointed to see to the maintenance of the permanent way in a pre-determined section, the length of which is from 4 to 15 km. (2.5 to 9.3 miles) according to whether it is a main line, secondary line, single track, double track, etc.

As a general rule, these gangs are distributed uniformly along the line, except in large stations where the gangs have to be reinforced in proportion.

For special work, such as skilled work, the maintenance of signals, bridges, electrical installations, etc., the railway administrations possess according to the extent of their lines a special staff of specially trained workmen.

The work of guarding the track is carried out on most railways by keepers, often also by workmen; at the level crossings provided with barriers, there are gate-keepers to watch the crossing; on some railways, as in *Switzerland*, women also are employed for this duty.

Recently, the barriers on the track have been replaced by light signals, for example on the *Swedish* Railways.

The supervision of tunnels and bridges as a general rule is allotted to the line watchmen; special watchmen are detailed for dangerous parts of the line.

This organisation differs on the *Swedish* State Railways, the lines of which are distributed into sections for a line watchman; each watchman has to watch a section of 2.3 km. to 8.2 km. (1.43 to 5.1 miles) depending upon the importance of the line. The watchmen watch the line in their section and also carry out the maintenance work. In Summer, two labourers work with them, specially engaged for the duration of the most important work.

The gangs, skilled workmen and watchmen are supervised by track inspectors; the length of their districts varies according to the extent of their authority. The track inspectors have to cover their districts, either by train or on foot, daily or at intervals. The superiors of the track inspectors are the permanent way engin-

eers, who are always in charge of several districts of track inspectors.

QUESTION 2. — *Innovations introduced in recent years with the object of effecting permanent way maintenance more economically.*

The means which have been used with the view of making the work of maintaining the permanent way more economical are as follow :

Use of mechanical appliances and instruments (*Denmark, Finland, Czechoslovakia*) increase in number of sleepers, replacing packed ballast by broken ballast; drainage of earth-work; use of motor trolleys for the transport of material (*Switzerland, Czechoslovakia*); replacing the line watchmen by workmen (*Sweden*); reduction in the gangs (*Bernese Alps Railway*).

QUESTION 3. — *What is the most recent equipment of your permanent way ?*

- a) *Main line;*
- b) *Secondary line;*
- c) *Weight and length of rails, system of joints, number and kind of sleepers, method of fixing the rails to the sleepers, type of ballast.*

According to the replies, the railway administrations employ mostly on the main lines, Vignoles rails weighing 44 kgr. per m. (82.7 lb. per yard) (*Bulgarian State Railways*) to 46 kgr. per m. (92.7 lb. per yard), (*Norwegian State Railways*), of the ordinary lengths of 12 to 20 metres (39 ft. 4 1/2 in. to 65 ft. 7 3/8 in.) with suspended and fixed joints (supported on two sleepers) with wooden and steel sleepers; for fixing the rails to the sleepers, use is made of sole plates, clips, bolts and coach screws; for the ballast, broken

stone, packed river gravel and sand are used.

The *Czechoslovakian State Railways* in addition employ in tunnels double headed rails weighing 47.1 kgr. per m. (94.9 lb. per yard), and 15 m. (49 ft. 2 1/2 in.) long on 21 sleepers.

On the secondary lines, a light type of rail of a minimum weight of 20 kgr. per m. (40.3 lb. per yard) is sometimes used (*Greece, North-East Railways*), and sometimes material from the main lines is employed. As regards the joints, the number and type of sleepers, fixing the rails, rules similar to those in force on the main lines are applied. For the ballast, the cheaper varieties of ballast are mostly used.

QUESTION 4. — *What is the average length of line kept in repair by a gang?*

*How many platelayers including the foreman are there in a gang, including the foreman platelayer, and if there are any, his assistant and the under foremen, on:*

- a) *Main lines;*
- b) *Secondary lines?*

QUESTION 5. — *Do you employ formulæ for determining the number of workmen necessary for the maintenance of a certain length of track (single track or several tracks)? If so, what are these formulæ?*

*How do you introduce into these formulæ the length of accessory tracks and the number of switches which are equivalent to a certain length of main line track?*

QUESTION 6. — *Is the number of workmen in a gang constant winter and summer, or do you have gangs formed of a limited number of workmen, who are*

*permanent employees of your administration, supplemented in summer by temporary workmen?*

QUESTION 7. — *What other duties are allotted to the gangs such as: cleaning ditches, keeping hedges in repair, etc., or is such work entrusted to contractors?*

According to the replies to questions 4, 5, 6 and 7 (see Appendix III) the basic working unit for most administrations is the gang as already mentioned in the replies to the first question.

The average length of line allotted to a gang varies from 4 to 12 km. (2.5 to 7.5 miles) on the main lines; on secondary lines from 4 to 15 km. (2.5 to 9.3 miles). The number of workmen permanently employed in a gang (during the whole year) again varies from 4 to 12. These workmen are, as a general rule definite employees of the railway; this number is increased by temporary employees during the principal work of permanent way maintenance.

The number given above usually includes also the number of workmen necessary for the relief of the track watchmen, and as supplementary workmen in stations, warehouses, etc. The *Swedish* and *Finnish* railways — as already stated in the replies to the question 1 A — do not work with gangs organised in this way but, as a general rule, the maintenance work is carried out by track watchmen under the control of the inspectors, and they are allotted a number of supplementary workmen during the period when the principal maintenance work is done.

The number of workmen required in forming a gang is determined by some railways, for example, the *Danish, Egyptian, Luxemburg, Roumanian* and *Czechoslovakian* railways according to for-

mulæ, which fix empirically the number of workmen necessary for the maintenance of a kilometre of complete track, or also of station tracks (main, secondary).

*The number of men necessary for the maintenance of one kilometre of single track main line, as determined by these formulæ, varies between 0.6 and 1.2 men; for the maintenance of 1 km. of single track main line, the average is about 0.8 man (1.3 men per mile); for the maintenance of 1 km. of double track main line, about 1.5 men (2.4 men per mile).*

The formulæ employed are simple, but they are not sufficient for determining exactly the labour required, and still less for strictly ascertaining the maintenance costs, in view of the fact that no allowance is made for very important factors, such as :

- a) Conditions of the road and gradient;
- b) Conditions of the earthwork;
- c) Quality of the ballast;
- d) More exact distinction of the types of track in stations (whether the tracks are used by passenger trains or only by goods trains or whether the track in question is a sidings track, etc.).

Taking 1 km. of track as the basic length for maintenance, it is a matter of converting, on all the lines entering into consideration, 1 km. of all the existing tracks (full tracks, lines of one or more tracks, main and secondary station tracks, etc.) in terms of a uniform measure, called «reduced or equivalent kilometre». This is obtained by increasing or reducing in proportion, or generally, by reducing the kilometre of an effective track determined by means of proportionately selected coefficients, on the basis of the experience gained, for all the details mentioned above and for others not mentioned.

In this way, lengths of sections of track and of entire lines are obtained in terms of equivalent kilometres, which have a similar value for all lines and for all kinds of track, and for these lengths it is possible subsequently to determine the number of workmen necessary for maintenance in a much more exact manner than by means of the formulæ hitherto employed.

The Administration of the Czechoslovakian State Railways has made a thorough study of this question, and in 1929 arranged for the length of its lines to be given in equivalent kilometres according to the above-mentioned principle. This Administration is also going to use, by way of trial, the results of this enquiry in order to determine the number of workmen necessary for maintenance work, as well as for studying the results of that work.

A few of the railways, chiefly the Egyptian railways, and some of the Swedish and Swiss railways, work with a constant number of men in a gang during the whole year. For most of the railways, however, this number is not constant, being less in winter, when the gangs are made up as a rule of permanent employees only, being increased by temporary workmen in summer according to the requirements.

In order to determine the number of permanent workmen (one could also say: in order to fix the winter effective of workmen), local conditions are obviously determinative, which conditions, of course, are not identical for all railways.

*In this connection, it is profitable and justifiable to start out from the principle that there should be no permanent employees for the maintenance of the superstructure except those who may be employed rationally at the period of least*

*work, which on most railways is in winter.*

(Extra work in connection with the removal of snow does not enter into the calculation.)

For the principal working season, that is to say, for the period from spring to autumn, the number of workmen is increased by means of temporary workmen.

As a general rule, the maintenance gangs also carry out accessory work, such as cleaning the approaches, looking after the hedges, etc.

On some railways, such work is done chiefly in winter.

QUESTION 8. — *For the permanent way maintenance, do you apply the system of continuous maintenance or the system of general periodic overhaul?*

*In the latter case, after what interval of time is the general overhaul repeated?*

QUESTION 9. — *In the case of maintenance by general overhaul, do you have this inspection made by the ordinary gangs or by special gangs inspecting the entire track?*

The *Guillaume-Luxemburg* Railways apply the system of general overhaul for the maintenance of the permanent way on all their lines; the *Czechoslovakian* State Railways on the main lines; the frequency depends upon the intensity of the traffic, the system and the quality of the superstructure, the quality of the ballast, etc.

The commonest intervals are from two to five years. The *Swiss Federal* Railways, at the present time, are employing the system of periodical general overhaul in a temporary manner. In the opinion of this administration, this system will not do away with the other (maintenance by continuous inspection). As regards

the interval at the end of which the inspection should be repeated, it is not yet possible to make any definite statement. The general inspections on the *Guillaume-Luxemburg* and *Czechoslovakian* railways are made by the ordinary gangs, reinforced — if necessary — by day labourers. Those on the *Swiss* railways are carried out to some extent by the employees of the railway, and also by private undertakings; in the latter case, the work is done on contract.

The last-mentioned system is chiefly employed when the whole of the ballast has to be removed.

The *Bulgarian* State Railways have abandoned the system of maintenance by general overhaul since the Great War, owing to the lack of means, but the system is to be put in operation again and the inspections will be repeated every three years.

All the other railways carry out the maintenance work of the permanent way on the continuous system.

QUESTION 10. — *What is the technical procedure in:*

a) *Preparing the material before being placed in the track;*

b) *The care bestowed on the material while in use, indicating the average life of the different materials;*

c) *Moving the track;*

d) *Tamping and straightening;*

e) *Cleaning and weeding the ballast?*

a) and b) As regards the preparation of the material before it is placed in the track, and the care to be bestowed on the material while in use, impregnation of wooden sleepers is employed almost universally. On some railways, sleepers that are not impregnated, rails and small material in tunnels, where galvanised coach

screws are also used (*Luxemburg*) are treated with pitch; in addition, the signals are cleaned and drained, and efforts are made to prevent as far as possible creeping of the rails by employing anti-creeping devices.

As a general rule, the necessary material is uniformly distributed along the track.

As regards the average life of the various materials, the following particulars are given by the Administrations:

In order to increase the life of the worn sleepers, the seats are re-adzed, the sole pieces are removed, sole pieces of poplar are placed in position and the sleepers are plugged. To increase the life of rails with worn ends, they are built up about the joint and the top face planed (*Luxemburg*).

As regards the average life of the other materials, the *Rumanian State Railways* alone state that the average life of the fishplates, bolts and coach-screws is 15 to 20 years and that of the sole-plates is 30 to 40 years.

The other administrations state that it would be very difficult to provide exact information on this subject.

c) As regards moving the track, only a few railways furnish interesting information; for example, the *Danish State Railways*, who, in the case of small movements, remove a portion of the ballast and reline the track without taking it apart. For moving the track over large distances, the track is taken up and re-erected in the desired place;

d) Tamping is done either by hand or by compressed air tampers (see first part of the questionnaire); as a rule, straightening is done by hand;

e) As a general rule, the ballast is cleaned by forking or by screening; weeding of the ballast is done by hand

or by ballast ploughs (*Denmark, Sweden*), by the « *Scheuchzer* » weeding machine (*Switzerland*) or by means of chemical substances (watering with sodium chlorate) in *Denmark and Luxemburg*; sodium chlorate in *Sweden*.

QUESTION 11. — *Do you have certain work done on contract by your own employees, or do you grant bonuses for work done in a fixed time?*

*If so, what are these bonuses expressed in terms of wages?*

*How is the work supervised in such cases?*

*Has the method of carrying out the work of permanent way maintenance on contract or with bonuses a bad effect on the exactness with which the work is done?*

*What is the annual cost per kilometre of single track?*

The railways of *Bulgaria, Denmark, Egypt, Finland, Greece, Luxemburg, Norway, Rumania, Yugoslavia and Switzerland* have all permanent way maintenance work done by their own employees on day-work; there are neither piece-work nor bonuses. On the *Swedish State Railways*, the temporary workmen do certain work on contract, but only when it is possible to see that the work is done properly. The details relating to this work are not given.

The *Czechoslovakian State Railways* have some of the work of renewing the superstructure done by contractors and are very satisfied with this method of working. It is merely necessary to supervise very closely the work done by the contractor. The maintenance work properly so-called is done only by the employees, who have neither contract work nor bonuses.

As regards the cost per annum of main-

Name of Railway Administration.	Average life of sleepers.		
	Wood.		Metal.
	Impregnated.	Non-impregnated.	
Denmark . . . . .	20 to 25 years.	...	...
Egypt . . . . .	10 to 20 years.		...
Luxemburg . . . . .	27 1/2 years.	...	...
Rumania . . . . .	15 to 20 years.	...	...
Yugoslavia . . . . .	12 to 15 years (beech sleepers).	8 to 12 years (oak sleepers).	...
Sweden (*) (Stockholm-Roslags).	16 to 20 years; (*) 30 years.	8 to 10 years; (*) 12 years.	...
Switzerland . . . . .	20 years.	...	25 years.
Czechoslovakia . . . . .	20 to 25 years (beech and oak creosoted sleepers); 10 to 15 years (pine sleepers).	10 to 15 years (oak sleepers); 5 to 7 years (pine sleepers).	...

Name of Railway Administration.	Average life of rails.	
	In main line tracks.	In tracks of secondary or goods lines.
Denmark . . . . .	From 25 to 40 years (total life?).	
Egypt . . . . .	From 25 to 40 years (total life?).	
Luxemburg . . . . .	From 25 to 30 years.	20 years (rails obtained from main lines).
Rumania . . . . .	From 30 to 40 years (total life?).	
Yugoslavia . . . . .	From 30 to 35 years, also 50 years; in future, an average life of 20 years will be reckoned in the main lines, and then these rails will be used in the secondary tracks.	
Sweden . . . . .	From 15 to 30 years (total life?).	
Switzerland . . . . .	25 years.	Not given.
Czechoslovakia . . . . .	From 20 to 30 years.	25 years (rails from the main line tracks).

taining the permanent way, the *Egyptian State Railways* indicate that the annual maintenance cost is 1 632 gold-francs per kilometre (2 638 gold-fr. per mile) of single track (excluding renewals and the maintenance of bridges), and the *Stockholm-Roslag Railways* indicate this cost to be \$ 60 to 100 (\$ 96.5 to 160 per mile).

The other Railways do not give any positive information regarding this cost.

QUESTION 12. — *What is the working day for ordinary platelayers? Is this day fixed by law?*

*If so, has any distinction been drawn between ordinary work, overtime work and urgent work?*

QUESTION 13. — *If the working day is fixed by law, is the time counted from the moment the workman arrives at the place where work is to begin, or from the moment he arrives at the point on the railway territory nearest to his dwelling?*

The working day is fixed by law at 8 hours for the following administrations: *Finnish State Railways*, and the Railways of *Luxemburg*, *Norway*, *Yugoslavia*, *Bulgaria*, *Switzerland* and *Czechoslovakia*.

The working day may be extended in cases of urgency, such as: accidents, work which has to be done in the interests of the safety of the traffic, extra accumulation of work etc.; but the number of hours worked on this overtime per year is limited by law, and is regularly combined with extra wages or a reduction in the working day.

In *Rumania*, 10 hours are worked in summer and 8 in winter; in exceptional cases the day is increased up to 12 hours, with overtime pay.

The *Swedish State Railways* give the

effective working day as 8 hours which is not fixed by law.

The *Danish State Railways* state that the average working day is limited to 8 1/4 hours, without being fixed by law. The working day for the railways of *Egypt* and *Greece* is 9 hours without being limited by law. The *Göteborg-Boras* (Sweden) Railway states that the working day is not legally fixed for their staff but that arrangements are made with the staff in charge of the inspection and maintenance work according to which the working periods are estimated for 6 months in summer with a 9 hours' day, and 6 months in winter with a 7 hours' day.

The administrations of the *Stockholm-Roslag* and *Nora-Bergslagen* Railways indicate a similar adjustment of the work.

The time is regularly counted from the moment the workman has arrived at the place where the work is to begin.

The *Danish State Railways* mention that when special tools or materials have to be transported to the place of work, the necessary number of workmen is ordered to be at the depot when work begins, and in this case the workmen must arrive at the working place later. The same applies when tools, etc., have to be returned to the depot.

The Railways of *North-West Greece* count the time from the moment the workman reaches the point on the railway territory nearest his dwelling. The *Rhaetian Railway* pays the workmen for half the time required in coming the distance from their dwellings to the place where work is to begin, if this distance is greater than 4 km. (2.5 miles) (journey on foot), or if the journey by train exceeds one hour.

QUESTION 14. — *Do you employ rail motor vehicles to take the workmen to their place of work?*

*State the conditions under which these vehicles are run.*

The railways of the *North-West of Greece* utilise trolleys for this transport.

Several *Swedish railways* (*Västergötland-Göteborg*) transport their workmen in light vehicles belonging to the administration; on the *Nora-Bergslagen* Railway, the workmen employ tricycles which are their own property.

The *Swiss Federal Railways* transport employees who have to carry out important work (particularly work in tunnels) to the working place by special transport (in a coach or a rail motor coach). In cases of this nature, the duration of work is counted from the time that transport begins.

The *Czechoslovakian State Railways* employ rail motor vehicles (see first part of the Questionnaire) to conduct the workmen to the place of work, especially in cases of important work, and also on secondary lines, where the gangs would have to cover long distances on foot, which would entail a considerable loss of time.

None of the other railways have provided any positive information on this subject.

QUESTION 15. — *Are the skilled workmen (carpenters, painters, stonemasons, etc.) and the signals and telegraphs employees provided with means of transport, either bicycles or rail motor coaches?*

*In the first case, are the bicycles the property of the administration, or do the employees receive an allowance for their upkeep?*

On the *Danish Railways*, the employees in question are provided with rail bicy-

cles, hand trolleys or motor trolleys. These vehicles are the property of the administration.

On the *Railways of Yugoslavia* and on those of *Rumania* and *Czechoslovakia*, the telegraph employees alone are provided with trolley-bicycles, which in *Rumania* and *Czechoslovakia* are the property of the Administration, and in *Yugoslavia*, the property of the employees, who receive an allowance for their upkeep.

On the *Bulgarian State Railways*, the employees in question are transported by means of motor trolleys and small wagons.

On the *Swedish* railway systems, the skilled workmen dealing with the signals are provided with rail motor cars which are the property of the administrations, and only on one railway (*Västergötland-Göteborg*) the property of the employees.

On the *Swiss Railways*, motor trolleys are utilised belonging to the railway (*Federal Railways*); on the *Rhätian Railways*, only the men working on electrical plant and contact lines employ such vehicles; some of the permanent way watchmen on these railways use trolley-bicycles.

All the other administrations give negative replies to this question.

QUESTION 16. — *Measures taken to increase the life of the material in accordance with the importance of the traffic.*

The *Danish* and *Egyptian State Railways* are introducing ballast which does not lose its elasticity, and are increasing the number of sleepers.

The *Rumanian State Railways* mention general overhauls, tightening the bolts, oiling of joints, etc.

The *Railways of Yugoslavia* increase the depth of ballast and use heavier rails,

devoting greater attention to maintenance and using in addition sole plates on each sleeper.

QUESTION 17. — *Graph of the progress of all the works mentioned showing the economical results.*

1. *Have you determined and fixed by graphs as a result of exact observations of the operations carried out on your lines, the normal standard time required for each partial operation or for all the important works to be carried out on the track, for example :*

A. *For handling material;*

B. *Maintenance work proper.*

2. *In fixing the standard normal operations, how have you allowed for time lost owing to train traffic or to other causes ?*

At the Headquarters of the *Guillaume-Luxemburg* Railways, graphs are made and revised monthly by the district engineers and contain all the information necessary for following the output obtained (strength of the gangs, number of working days, replacement of material, etc.).

The *Rumanian State* Railways only show general observations regarding the progress of the maintenance work proper which may be applied in rather wide limits, because the circumstances and the means in and with which the work is done do not allow exact rules to be drawn up.

One may allow :

For tamping one sleeper with gravel ballast, 1 man-hour.

For adjusting 1 metre of track in plan and elevation 1 man-hour (0.91 man-hour per yard).

For general overhaul, according to the type of track, 1 metre as a rule, 2.5 to 1.2 man-hours (2.28 to 1.09 man-hours per yard).

For the complete renewal of 1 metre of permanent way, type 45, usually, 5 man-hours (4.57 man-hours per yard).

The time lost owing to train traffic is included in fixing the operations indicated above in accordance with the practice of the railway.

The Railways of *Yugoslavia* do not use the graphs in question, but the following figures have been determined for the men required to carry out the work (for a working day of 8 hours):

	Workmen.
A. Loading 1 ton of rails.	0.4
Unloading 1 ton of rails.	0.3
Loading 1 m <sup>3</sup> (1 cubic yard) of ballast . . . . .	0.18 (0.137)
Unloading 1 m <sup>3</sup> (1 cubic yard) of ballast, etc. . . . .	0.10 (0.076)
B. Renewing 1 m. (1 yard) of rails . . . . .	0.04 (0.036)
Tamping 1 sleeper . . . . .	0.12
Renewing 1 sleeper on the open track. . . . .	0.25
Weeding 1 m. (1 yard) of track . . . . .	0.03 (0.027)
Renewing 1 m. (1 yard) of track . . . . .	0.7 (0.64)
Assembling a complete switch without laying it in the track . . . . .	50

The time taken to do a certain piece of work is the average time.

On lines where the traffic is considerable and where the interval between the trains is small, the time in question is increased by 25 to 30 %.

On the *Rhetian Railway*, all the maintenance operations are fixed each month by analysing exactly the time necessary

for these operations. In this way, the standard costs of maintenance work are fixed for each year.

The Swiss Federal Railways do not use the graphs in question, and they have merely made a few special observations, without having drawn up any tables on this subject.

The Czechoslovakian State Railways, on the basis of trials extending over several years, have introduced a close supervision of maintenance work on the track, and the results obtained are employed in determining the normal units of work. This supervision was made legal by a special regulation in 1927.

Each foreman platelayer records daily all the operations carried out on the permanent way by his gang on special returns giving among others the following particulars :

1. Kilometre of the line where the work was done.
2. Description of the work.
3. Standard measure.
4. Amount of work.
5. Number of men working.
6. Time necessary for the work.
7. Number of hours and minutes of work.
8. Number of trains during the time that work was in progress.
9. Time lost :
  - a) Owing to train traffic.
  - b) Other causes.
10. Number of hours and minutes of work without loss of time.
11. The standard number of hours and minutes of work.

The foreman platelayer enters up on the return the items 1 to 9 according to the actual work done. The track inspec-

tor checks the entries of the foreman platelayer, calculates the items 10 and 11, enters the standard measures for each operation on special monthly returns, and this he does separately for each gang. The operations are entered up according to the list of standard operations, which are also given in appendix IV (description of details of the work).

The work is divided into :

- A. Work relating to the material itself.
- B. Maintenance work proper.
  - B-I. Rails.
  - B-II. Sleepers.
  - B-III. Ballast.
  - B-IV. Switches and crossings.

All the standard operations on the permanent way, to which a uniform measure is applied, number 106. The sections of the way and works department check the work on the track and the monthly reports of the track inspectors. They endeavour to bring up the necessary reinforcements where the isolated gangs are insufficient and at the end of the year they draw up annual reports, showing the average time taken for the operations which form a basis for estimating the output of the gangs in the following year.

When the average time taken for the operations was determined, in the first year this system of control was put into force, the exact time lost due to traffic or otherwise was obtained. A close observation, extending over a whole year, enabled the average loss of time due to train traffic to be ascertained, and consequently these regular losses are not checked, but are at the present time included in the calculation by an average coefficient obtained by means of observations taken over a whole year as mentioned above. The losses in time in the large stations have not been ascertained owing to

the fact that shunting is always in progress; the work on the superstructure in these stations is ascertained by means of special reports. All the results of the work are shown annually, as already stated, in annual reports and graphs, according to Appendix IV. In this Appendix the maintenance work on all the first grade lines of the Czechoslovakian State Railways for 1927 is shown so as to emphasize:

- a) The mutual relationship between the various operations;
- b) The mutual relationship between the main operations;
- c) The mutual relationship between the time lost in these operations.

For instance, the graph shows that:

- a) The maintenance of the height requires 32 % of the total work;
- b) The renewal of sleepers requires 40 % of the total work;
- c) The maintenance of the track in line requires 6.5 % of the total work;
- d) The forming of the ballast bed requires 15 % of the total work. The time lost:

- A. is 10 % of the hours worked.
- B-I. is 6 % of the hours worked.
- B-II. is 6 % of the hours worked.
- B-III. is 6 % of the hours worked.
- B-IV. is 7 % of the hours worked.

All these data and others relating to the graphs and written returns, which it is not possible to enumerate here, serve as an exact basis for determining the actual time necessary for the work, and for comparing the results of the work not only of the individual gangs but also the sections of the permanent way department in one division, as well as on the whole of the Czechoslovakian State Rail-

ways possessing and operating more than 30 000 km. (18 640 miles).

*These data are employed partly for standardising the normal duration of the operations, or also for eliminating unnecessary work, for rapidly ascertaining disturbances in the work, and for eliminating the causes of these disturbances.*

The results of this system of control or check have been very good, despite the initial difficulties of the foremen platelayers in having constantly and accurately to enter up the particulars of the various operations and the time lost. These difficulties have been reduced owing to the practice gained by the foremen platelayers and to the introduction of average time losses.

The other administrations have not furnished any detailed or positive data relating to this question.

QUESTION 18. — *Professional instruction of the employees appointed to direct and carry out this work.*

*Method of selecting these employees.*

*Are these employees required to possess official or professional qualifications?*

*Does the Administration facilitate the instruction of these employees?*

*If so, give details of the organisation of such schools.*

As regards requiring the employees appointed to direct and carry out the work of maintenance and supervision of the permanent way, to possess official or professional qualifications, one administration only, the Swiss Federal Railways, states that it does not demand such qualifications from the district foremen.

As regards the manner of selecting and instructing the maintenance and supervising staff, detailed information has

been provided on this point by the administrations in their replies to Question XVI of the programme of the 1930 Madrid Congress : « Methods followed in training of staff, professional, technical and ordinary working grades ».

It is useful, however, to reproduce here the more important particulars relating to the selection and instruction of the permanent way Department staff as given in the reports of the railway administrations which show widely differing methods.

The *platelayers* are recruited in some administrations after a simple examination (*Luxemburg, Czechoslovakia*).

The *foremen platelayers* are regularly

selected from among the more capable platelayers.

For the platelayers considered suitable for this promotion, instruction courses and schools are organised by several administrations.

The *Danish State Railways* organises such courses according to requirements; lessons are given in these schools on railway calculations, organisation and technicalities, elementary land surveying, as well as the principles of signalling plant, etc.

The *Czechoslovakian State Railways* organise courses covering the following programme :

	Education.	
	Theory, 6 weeks.	Practice, 4 weeks.
Track . . . . .	80 hours.	168 hours.
Formation, etc. . . . .	24 —	24 —
Instruction in signals and traffic . . . . .	52 —	...
Guarding the track . . . . .	42 —	...
Elementary education . . . . .	27 —	...
Book-keeping . . . . .	21 —	...
Service and working orders . . . . .	6 —	...
Buildings . . . . .	12 —	...
Total . . . . .	264 hours.	192 hours.

The remaining Administrations do not give any detailed or definite particulars pertaining to courses or schools for foremen platelayers.

The Administration of the *Egyptian State Railways* requires the foremen platelayers to be able to read and write and to know the four rules of arithmetic.

On the *Luxemburg Railways*, the assistant foremen, called section assistants,

are recruited from the platelayers, who have to pass an examination to be promoted to this rank. The foremen platelayers are recruited from the ranks of the assistant foremen.

The *Rumanian State Railways* give their foremen platelayers a special course of instruction at a school, the courses lasting six months.

As regards the selection of the *district*

*foremen* (gang inspectors, track inspectors, foremen platelayers in Norway) the following information is provided by the Administrations :

The gang inspectors on the *Danish* Railways have to be skilled workmen. Before being appointed gang inspectors, they have worked for several years as draughtsmen in the offices of the Railway, after which they receive their practical instruction.

The district foremen of the *Egyptian* State Railways, called track inspectors, were recruited until recently, from the ranks of the foremen platelayers. It has just been decided to recruit them from among the young men who have got their diploma from the School of Arts and Crafts, after they have completed a certain period of training as foremen platelayers.

The district foremen on the *Luxemburg* Railways are recruited from the ranks of the foremen platelayers by means of courses instituted at the head office before each examination in order to facilitate the preparation of the candidates.

The syllabus of the examination for the rank of track inspector (district foreman) is composed of the following parts:

### TESTS.

#### A. — *Written.*

1. Report on a service matter written in French.
2. Small scheme, including report with quantities, estimate of costs, calculations and drawings.
3. Draft scheme for a small structure or part of a building (merely giving the dimensions without particulars of the operations carried out).
4. Sketch of a structure or a building

or part of a building or of an appliance with the necessary dimensions.

5. Drawing and colour-washing sections.

6. Drawing up a scheme of work on contract or by direct labour.

7. Drawing up a scheme for an alteration to the interlocking or to a switch-board.

8. Translation into French of a German text.

9. Short report in German.

#### B. — *Oral.*

10. Conversation in German.
11. Elementary mechanics.
12. Elements of the strength of materials.
13. Elements of theoretical and applied electricity.
14. Surveying and levelling.
15. General ideas on railways.
16. Railway and permanent way practice.
17. Practice of earthworks and building construction.
18. Signalling and safety devices.
19. Telegraph and telephone lines and apparatus.
20. Miscellaneous administrative knowledge of railway organisation and service, personnel, book-keeping and the everyday working service in the districts.
21. Track supervision and level crossing protection.
22. Administrative law limited to simple railway problems.

### PRACTICAL TESTS.

23. Survey including tracks, of 4 to 5 ares (430 to 540 sq. feet):  
In the field.  
In the drawing office.
24. Levelling with a spirit level, keeping a field note book :  
In the drawing office.

On the *Czechoslovakian State Railways*, the track inspectors must be skilled workmen (stonemasons, carpenters, etc.) and hold the diploma of an elementary technical school. In addition, schools are organised for the track inspectors, the syllabus being as follows :

Administrative service and book-keeping . . . . .	60 hours.
Instruction on signals, traffic and transport . . . . .	50 —
Special instruction in track work . . . . .	20 —
Instruction in connection with materials . . . . .	55 —
Instruction in track inspection and the economic control of maintenance work .	55 —
Instruction in safety matters.	50 —
Building materials . . . . .	50 —
Formation, etc. . . . .	110 —
Track . . . . .	190 —
Buildings . . . . .	60 —

Total. . . 700 hours.

The course lasts twenty weeks.

The *Norwegian State Railways* require the departmental foremen called foremen platelayers to possess the diploma of an elementary technical school or of a higher grade technical school. In addition, courses are organised for the education of the junior employees. The personnel appearing to be qualified for promotion may take these courses in order to be appointed foreman platelayer. Certificated teachers or employees are employed to give instruction in certain subjects.

The district foremen on the *Yugoslav Railways*, called supervisors, have to hold the diploma of a technical school and pass the prescribed examinations.

The Administration arranges courses of study for the assistant supervisors, who receive practical and theoretical

instruction (arithmetic, geometry, mechanics, earthworks, superstructure, bricklaying, safety plant, signals, administration, hygiene and technology).

The district foremen of the *Swiss Federal Railways* are generally selected from the platelayers. They gain their practice in the first place as foremen platelayers and later as assistant to the district foremen (track inspectors). The Administration supplements the instruction of these members of the staff by courses which are organised from time to time, but which have not the character of a school. They are not held according to any fixed plan.

The *Bulgarian State Railways* supplement the instruction of the supervisors by special schools. The syllabus of these schools is not given.

In addition, with the view of perfecting the knowledge of the employees, there are official instructions and lectures for the maintenance and supervising personnel as well as for the signal employees.

The section and district foremen, on their rounds, frequently interrogate the men they meet (*Luxemburg, Yugoslavia, Czechoslovakia*).

For the section foremen (chef de section) a civil engineer's diploma is generally required.

## SUMMARY.

Replies to the questionnaire have been given by nineteen Administrations in all. The length of the lines of these Administrations differs considerably, and varies to a great extent for one Administration.

It is evident that in view of these circumstances it is impossible to compile a summary giving an accurate picture of all the details and requirements of all the Administrations under consideration.

Arrangements which are advantageous for large Administrations are not and cannot always be profitable for Administrations of less importance and vice versa.

Nevertheless, on the basis of the information received, the following statements and recommendations may be made :

1. It follows from most of the replies that have been given that the endeavours and measures aiming at the rationalisation of all the permanent way maintenance work and tending to reduce working expenses to a measure corresponding to a rational organisation of the work, continue to show themselves in a more intensive fashion.

2. The basic unit of labour for the carrying out of permanent way maintenance work is, and undoubtedly will remain in the future, the gang.

The average length of the lines allotted to a gang, and the number of workmen in a gang evidently depend upon quite a number of factors, as mentioned in detail in point 3.

3. In order to obtain exactly the number of workmen necessary for the work of permanent way maintenance, several Administrations make use of empirical formulæ by means of which the number of workmen required for the maintenance of 1 kilometre of track is ascertained.

It is advisable that this number of workmen should be determined with the greatest exactitude possible.

A suitable method for example would be to express the lengths in kilometres of all the lines and tracks entering into consideration in terms of the equivalent kilometres so that the actual lengths in kilometres of the different kinds of lines, as well as the actual lengths of the tracks in stations and elsewhere, are increased

or diminished, or to speak in a more general fashion are *equated*, by employing coefficients obtained by a series of exact observations taking into account :

a) The conditions under which the track is laid and the gradient.

b) The quality of the formation on which the track is laid.

c) The type and the age of the track.

d) The quality of the ballast.

e) The fact of whether the line has one or several tracks, whether it is a station track, etc.

f) The importance of the traffic on the line, the number of trains, the speed of the trains, etc.

In this way, the lengths of all the lines and tracks are expressed in terms of equivalent kilometres, which *for this reason, have an identical value (quality) for all kinds of lines.*

At the same time, a determination is made, according to the average for at least 3 to 5 years, of the average number of working hours required per annum for the maintenance of the permanent way on a certain line. If this number of hours is divided by the number of equivalent kilometres, the result is the number of working hours necessary for the maintenance of the permanent way for an equivalent kilometre. Given that, according to the above theory, the value of equivalent kilometres is identical for all the lines; then if the coefficients for the conversion are selected in a suitable manner, the number of hours of work necessary for the maintenance of the permanent way of an equivalent kilometre ought theoretically to be the same for all the lines, or from the practical point of view, *there should not be any appreciable differences in this number, as otherwise*

*it would mean that the equivalent kilometres have not been suitably selected. When no such differences are to be found, and yet considerable discrepancies are found in the number of working hours, the cause for these differences lies either in the work having been done irregularly or in other circumstances.*

It devolves on the Administrations to ascertain these circumstances and obviate them.

The number of hours of work necessary for the maintenance of the permanent way for an equivalent kilometre is also used to determine the number of workmen necessary for this work during the whole year, and after that, the number of workmen for each gang.

Next, and this depends upon certain circumstances, mainly climatic conditions, it is a question of knowing whether the number of men in the gangs remains constant during the entire year, or whether it is necessary to determine the *minimum effective of a gang* (an effective which in most administrations, is less during the winter season, at which period the ground is frozen and covered with snow, so that permanent way work is reduced to a minimum) and whether it is necessary to increase the number of workmen for the principal working period, from spring to winter.

4. A very important factor relating to the economic execution of permanent way maintenance work is a suitable type of track.

With few exceptions, the administrations mentioned in the present report employ, on their main lines, a permanent way with rails of 41 to 49 kgr. per metre (82.7 to 98.8 lb. per yard).

The average life of the track on the main lines may be estimated, according to the replies received, at 25 years, that

is to say, it is necessary to renew annually on the main lines, at least 4 % of the total length of line.

The material obtained from the main lines may be used to advantage as a general rule when relaying secondary lines and even station tracks.

The ultimate life of main line track with rails of 41 to 49 kgr. (82.7 to 98.8 lb. per yard) transferred at the end of 25 years and employed for relaying secondary lines may be estimated on an average as 25 to 30 years, and exceptionally even 40 years.

Assuming a normal relaying of the main lines (4 %) and that the track is suitably utilised on secondary lines and station tracks, this manner of economising on the track appears to be one of the most profitable, although the stronger track may not always be made full use of on secondary lines, having regard to the intensity of the traffic and the load per axle. As a general rule, this circumstance is sufficiently compensated by the economies in maintenance resulting from the stronger permanent way, which suffers less from the traffic than lighter track. The principal advantage in utilising the track obtained from another line obviously lies also in the saving in first costs.

5. As an important measure, tending to reduce maintenance costs, mention should be made of the efforts being made to reduce the number of rail joints which require relatively the greatest care as well as the heaviest costs in maintenance materials and labour.

These efforts consist in :

a) Laying the track with rails 20 m. (65 ft. 7 3/8 in.) and more long;

b) Laying the track with rails with welded joints in lengths of 30 to 60 m. (98 1/2 to 197 feet) and, in exceptional instances, still longer.

The measures mentioned are not indicated in detail in the replies received. It should be stated that at the present time these measures are being developed to a considerable extent on the railways of Central Europe. As regards the welding of rails, this is restricted, as far as can be ascertained, at the present time to track in tunnels, to lines without fast traffic and to station lines, particularly in shunting yards.

This is undoubtedly a *very important matter, deserving of the greatest attention from both the technical and economical standpoint.*

6. A very important task devolving upon the maintenance of the permanent way is to prolong as much as possible the life of sleepers, and especially of wooden sleepers which are the most frequently employed.

Oak sleepers first come into consideration, then beech and finally pine. With few exceptions all these kinds of sleeper are creosoted.

Bearing in mind the rise in price in the world's timber markets, it is advisable to investigate, in the closest manner, the present methods of creosoting wood and to decide the question of knowing if it is possible, and by what method of impregnating, to increase the present average life of the sleepers (for oak and beech sleepers, 20 to 25 years, for pine sleepers, 15 years), without increasing the cost of preserving, and at the same time if it is possible to solve the problem of replacing wood sleepers in the future by sleepers of other material, and especially of reinforced concrete, taking exact account of the results of trials now being carried out by several railways (France, Italy, etc.).

7. It has been ascertained that one of the causes of abnormal maintenance costs

and premature wear of the track is the poor quality of the ballast and lack of drainage. That is why it is indispensable to devote the greatest care to the good quality and the proper thickness (in depth and breadth) of the bed of ballast.

The cost of arranging a perfect bed of ballast, sufficiently thick and well drained, is absorbed as a rule in a few years by an essential reduction in the total maintenance cost, and *by the increased life of the track.*

It is to be recommended that particular care should be devoted also to the question of chemical methods for cleaning the ballast to clear it of weeds, to which question there has not been provided enough information to enable one to know exactly *whether this cleaning is really effective in practice and whether it is cheaper than weeding by hand.*

8. As regards the methods to be adopted for maintaining the track, for a short length of railway, the « continuous » method of maintenance work may be taken as a general rule as being sufficient.

For extensive railway systems, possessing main lines equipped with heavy track, very good results have been obtained, however, « by the method of general overhaul », and it is to be recommended that large railway administrations should duly observe and apply this mode of maintenance, one of the greatest advantages of which is the *systematic work in adjacent track sections.*

9. The hours of service, in most of the administrations, are fixed by law, and are usually 8 hours per day.

The working period begins when the workmen assemble at the place of work.

The manner in which the workmen get to the place of work varies widely. Some go on foot or by train; various kinds of vehicles are also employed, especially

bicycles, which the men provide themselves.

10. For the transport of workmen and other employees, especially those employed on the signals, small motor vehicles and trolleys are employed, and it is to be recommended that for moving workmen from one place of work to another these vehicles should be used as much as possible, since by this means, much time is saved and the work on the track is speeded up. The first condition is that the vehicles mentioned should be used on an extensive scale, not only for the transport of workmen, but also for hauling small wagons for the transport of materials, and for trolleys used in track supervision.

11. Up to the present, contract work and bonuses have not been used in connection with permanent way maintenance. The work is done almost entirely under the direct control of the railway administrations.

On a few large railways only, the relaying of the track structure is let out to contract. The results obtained are good and even very good; but obviously the work has to be *closely and constantly supervised*.

Despite of the present negative results, it is to be recommended that a continued study be made of the question of contract and bonus work in the track maintenance, in conjunction with an exact determination of the number of workmen needed (see paragraph 3) and with the supervision of maintenance work (see paragraph 14).

12. As regards the use of mechanical appliances, and the necessity of introducing mechanical work on the track this question has been dealt with already in the summary of the first part of the present report.

13. As regards the inspection of the permanent way, *the tendency to suppress barriers at level crossings*, and the substitution of signals, mainly optical, is making itself felt more and more, as is also the tendency to eliminate level crossings by the construction of bridges and subways.

Owing to the extraordinary increase in road motor traffic, this question is in constant evolution and is to be closely followed up as one of the most important problems of the future policing and supervision of railways.

14. The continuous observation of the results of the work done with the view of determining the normal or standard operations of work and their graphical representation have not been introduced generally. Still, we consider that it would be of great benefit in conjunction with all other efforts tending to an exact technical and economical method of working, to devote greater attention to this question, particularly in connection with the exact determination of the number of hours of work required for the maintenance of the permanent way (see paragraph 3). We should like to emphasize the extensive tests by the administration of the Czechoslovakian State Railways, mentioned in the present Report (question 17), carried out with the view of determining the standardised operations of work on the track and the losses of time caused. By making a constant and systematic comparison of the actual operations on the different lines, it is possible to obtain their desired standardisation as regards the time and the method of working as well as the reduction in the working costs.

On this basis it will probably be possible to consider likewise the introduction of trials with contract and bonus work in connection with permanent way

maintenance (see paragraph 11). It is recommended that the greatest attention should also be devoted to these questions in future.

15. The instruction of the maintenance and supervisory personnel is being successfully developed. Many administrations have organised special courses and founded schools with the view of obtaining a personnel most capable of supervising the maintenance work (foremen platelayers, supervisors, district foremen). In addition, the various administrations have increased the requirements relating to the preliminary education of the candidates for these posts. These are only the consequences of efforts aiming at making permanent way work and super-

vision as technically perfect as possible and at the same time most economical.

It is certain that the better the supervising members of the personnel, not only as regards their practical instruction, but also as regards their theoretical instruction, *obviously taking into account their sphere of action*, the better will be also the results of their activities.

It is impossible to recommend too strongly to the railway administrations that they should always devote the closest attention to the rational instruction and training of the supervising personnel of the permanent way service *as being one of the most indispensable conditions for the successful evolution of the organisation of this service*.

## Replies received to the first question

FIRST QUESTION : *What is the organisation*

NAME OF ADMINISTRATION.	A. — Organisation of the maintenance personnel.		
	a) <i>Uniformly distributed over the lines.</i>	b) <i>Concentrated at definitely selected places.</i>	c) <i>Personnel specially employed on the maintenance of signals, tunnels, bridges, etc.</i>
<b>Bulgaria.</b> <i>State Railways.</i>	Yes.	No.	...
<b>Denmark.</b> <i>State Railways.</i>	The railways are divided into sections, 6 to 10 km. (3.7 to 6.2 miles) long, in which a single gang carries out practically all the maintenance work. The gang is composed of a foreman platelayer, an under-foreman, 2 or 3 platelayers, and a variable number of day labourers. Each district is usually provided with a hut, in a station, for tools and materials together with a canteen for the men.	...	There is a number of men specially employed on the maintenance of signals, intelocking and telegraph plant.
<b>Egypt.</b> <i>State Railways.</i>	A gang of 7 to 8 platelayers is placed under the orders of a foreman platelayer. 6 to 7 foremen platelayers are placed under the orders of a track inspector; 5 to 6 track inspectors are placed under the orders of a chief inspector.	No.	Yes.
<b>Finland.</b> <i>State Railways.</i>	Day labourers under the direction of a line watchman.	No.	Erectors.
<b>Greece.</b> <i>North-West Railways.</i>	Yes.	No.	...
<b>Luxemburg.</b> <i>Guillaume-Luxemburg Railways.</i>	The personnel is distributed in gangs, each of which has the maintenance of a section of 6 to 8 km. (3.7 to 8 miles) of line.	No.	Specialised personnel, under immediate authority either the district foreman, or the section foreman.

the second part of the questionnaire.

the permanent way maintenance on your railway?

B. — Supervision and guarding of the permanent way.

a) In special works, tunnels, bridges, etc.	b) Level crossings.	c) Over the entire length of the permanent way.
No.	Yes.	Yes.
Special supervision is organised according to requirements.	On most of the State Railways the level crossings are kept by special employees, often by women.	The track is inspected regularly once a day by platelayers and sometimes by the higher staff.
guarding and maintenance of bridges is done by a special staff composed of one supervisor, or 2 fitters, a petty officer and a number of sailors according to the length of the bridge. There are no tunnels in Egypt.	The level crossings are guarded by the staff of the district inspector, day and night, or the day only, according to the traffic.	A platelayer has to walk daily over the sections of his gang, and to make sure that the bolts and coach screws are tight.
Bridge keepers.	Gate keepers.	Line watchmen.
...	Keepers.	Track watchmen.
specially appointed platelayers.	Some of the level crossings are guarded day and night, or by day, by keepers (men or women); the others are not guarded.	On important lines daily in the morning. The foremen platelayers in addition periodically inspect the section allotted to their gangs.

NAME OF ADMINISTRATION.	A. — Organisation of the maintenance personnel.		
	a) Uniformly distributed over the lines.	b) Concentrated at definitely selected places.	c) Personnel specially employed on the maintenance of signals, tunnels, bridges, etc.
<b>Luxemburg.</b> <i>Prince-Henri Railways.</i>	The railways are divided into sections; the length of each section may attain 25 km. A section is divided into several blocks, with foremen platelayers in charge of each block. Each foreman platelayer is in charge of the gang covering the block. The length of the block depends upon the traffic.	No.	Special skilled workmen.
<b>Norway.</b> <i>State Railways.</i>	Districts of 43 to 727 km. (27 to 452 miles). In the important districts, there are for maintenance work, an engineer in chief with one or more inspectors, each having a section attaining 200 km. (124 miles); the sections are divided into sub-sections, which are likewise divided into lengths (services) of 3 to 10 km. (1.86 to 6.2 miles) under a foreman.	No.	Specialist workmen.
<b>Rumania.</b> <i>State Railways.</i>	Gangs.	No.	Special workmen.
<b>Yugoslavia.</b> <i>State Railways.</i>	Each division has permanent way maintenance sections, supervisors and gangs of workmen. Each section is responsible for the maintenance of 100 to 200 km. (62 to 124 miles) of track. The length of track for maintenance depends upon whether the track is single or double, main-line or secondary, etc. Track supervisors are attached to the sections, with districts of 10 to 30 km. (6.2 to 18.6 miles). Each supervisor has 2 or 3 gangs of workmen, and each gang has its foreman. In addition, skilled workmen such as masons, joiners, carpenters, etc., are attached to each supervisor.		The maintenance of bridges is concentrated in the bridge erecting shops, the maintenance of safety plant is concentrated in the signals workshop which carries out maintenance by means of telegraph and signals supervisors who are distributed uniformly over the lines.
<b>Sweden.</b> <i>State Railways.</i>	The railways are divided into lines for track watchmen, each with a track watchman for maintenance and supervision. The number of track watchmen, including the reserve for sickness and holidays is greater than the lines covered. The watchmen are distributed uniformly over the railways. The length is about 2.3 km. (1.4 miles) on double-track main lines, about 3.3 km. (2.05 miles) on single-track main lines, and about 4.8 km. to 8.2 km. (3 to 5 miles) on secondary lines.	For maintenance in large stations.	Not generally.

## B. — Supervision and guarding of the permanent way.

a) In special works, tunnels, bridges, etc.	b) Level crossings.	c) Over the entire length of the permanent way.
See I/A.	Line watchmen and gate-keepers.	Line watchmen and gate-keepers.
See I/A.	Gate-keepers.	The guarding of the track is done by the maintenance personnel.
...	Gate-keepers.	By platelayers or track inspectors.
bridges, tunnels, etc., are supervised and guarded by track supervisors or special watchmen.	On lines where the speed of the trains exceeds 45 km. (28 miles) per hour, the level crossings are provided with barriers; on the other lines, there are barriers only if the level crossings are much used or if visibility is bad.	The supervision of the permanent way is generally done by the permanent way maintenance sections and guarding is done by line watchmen.
the supervision of weak points, the number of track watchmen is increased as required.	The level crossings are generally watched by women. In recent years, the supervising personnel at the level crossings has been replaced by optical and acoustical signals.	See A a).

NAME OF ADMINISTRATION.	A. — Organisation of the maintenance personnel.		
	a) Uniformly distributed over the lines.	b) Concentrated at definitely selected places.	c) Personnel specially employed on the maintenance of signals, tunnels, bridges, etc.
<b>Sweden.</b> <i>Göteborg-Boras and Boras-Alfvesta.</i>	The line is divided into sections about 30 km. (18.6 miles) long under track foremen. Each track foreman is in charge of 5 to 6 gangers who inspect the track every day and travel over it on trolleys. The rest of the time the gangers are employed on maintenance of the track or any other work connected therewith.		Tunnels are only attended to in the winter before the first train passes, with the object of removing any ice which may have formed on the rails.
<b>Sweden.</b> <i>Nora-Bergslagen.</i>	Four foremen, 40 track watchmen, and a variable number of workmen. Each track watchman has about 4 km. (2.5 miles) of line to watch.	No.	No.
<b>Sweden.</b> <i>Stockholm-Roslag.</i>	Yes.	No.	No.
<b>Sweden.</b> <i>Västergötland-Göteborg.</i>	A necessary number of track watchmen with a certain number of labourers.	No.	No.
<b>Switzerland.</b> <i>Federal Railways.</i>	The railways are divided into 3 main districts; these are divided into 20 sections, each under a permanent way engineer, 86 districts under district foremen, and 245 sections under section foreman, whose headquarters are distributed in a suitable fashion over the entire system.	See A a)	26 interlocking-plant gangs each comprising 2 to 5 employees and distributed uniformly over the whole system; a bridge gang in each main district, 23 sections for the electrical installations.
<b>Switzerland.</b> <i>Bernese Alps Railways.</i>	Distributed in groups over the lines.	See A a)	Controller of the interlocking and mechanical installations.
<b>Switzerland.</b> <i>Rhätian Railways.</i>	Seven districts with sections under foremen platelayers.	See A a)	See A a).
<b>Czechoslovakia.</b> <i>State Railways.</i>	All the railways are divided into track sections about 100 km. (62 miles) long. Each section is divided into districts 10 to 30 km. (6.2 to 18.6 miles) long and each district is divided into 2 or 3 sectors under foremen platelayers.	See A a)	Special personnel for the maintenance of signals and bridges uniformly distributed over the system.

## B. — Supervision and guarding of the permanent way.

a) In special works, tunnels, bridges, etc.	b) Level crossings.	c) Over the entire length of the permanent way.
The bridges are not subject to any special attention.	When the view is entirely clear, the level crossings are not guarded.	See A a).
No.	The level crossings are provided with barriers or optical signals.	Track watchmen, who are at the same time workmen.
No.	Yes.	Track watchmen.
Yes.	The level crossings are provided with barriers or optical signals.	Track watchmen, who are at the same time workmen.
See A a).	Gate-keepers, men and women.	Track watchmen. On lines where there is little traffic, the track is supervised by the platelayers, when going to, or returning from, work.
Track watchmen.	Gate-keepers.	Track watchmen.
Track watchmen.	Gate-keepers.	Track watchmen.
Track watchmen.	The level crossings are provided with barriers on lines where the speed of the trains exceeds 50 km. (31 miles) per hour. Such crossings are guarded by keepers.	The track is inspected regularly, by permanent way section engineers, once a week, by district foremen regularly 2 or 3 times a week, and by track watchmen once a day.

## Replies received to the third question

NAME OF ADMINISTRATION.		What is your most recent pattern of track?		
		Weight of rails in kgr. per m. (in lb. per yard).	Length of rails in metres (in feet and inches).	System of joints.
<b>Bulgaria.</b> <i>State Railways.</i>	a)	41 (82.7)	15 (49 ft. 2 1/2 in.)	Suspended joints.
	b)	34.8 (70.4)	12.15 (39 ft. 10 3/8 in.)	—
	b)	31.2 (62.9)	12 (39 ft. 4 1/2 in.)	—
<b>Denmark.</b> <i>State Railways.</i>	a)	45 (90.7)	15 (49 ft. 2 1/2 in.) 12 and 15	Joints supported on two sleepers.
	a)	37 (74.6)	(39 ft. 4 1/2 in. and 49 ft. 2 1/2 in.)	—
	b)	37 (74.6)	12 (39 ft. 4 1/2 in.)	—
<b>Egypt.</b> <i>State Railways.</i>	b)	32 (64.5)	10.9-7.3 (35 ft. 9 in.- 23 ft. 11 in.)	Suspended joints.
	a)	47 (94.7)	12 (39 ft. 4 1/2 in.)	Suspended joints.
	b)	46 (92.7)	12 (39 ft. 4 1/2 in.)	Suspended joints.
	b)	42 (84.7)	12 (39 ft. 4 1/2 in.)	—
	b)	37.4 (75.4)	8 (26 ft. 3 in.)	—
<b>Finland.</b> <i>State Railways.</i>	a)	43.6 (83.9)	12 (39 ft. 4 1/2 in.)	Not given.
	b)	30 (60.5)	12 (39 ft. 4 1/2 in.)	—
<b>Greece.</b> <i>North East Railways</i>	a)	...	...	...
	b)	20 (40.3)	8 to 9 (26 ft. 3 in. to 29 ft. 6 3/8 in.)	Supported joints.
<b>Luxemburg.</b> <i>Guillaume-Luxemburg Railways.</i>	a)	46 (92.7)	18 (59 ft. 5/8 in.)	On 2 sleepers, counter joints placed side by side, or suspended joints.
	a)	45 (90.7)	15 (49 ft. 2 1/2 in.)	Suspended joints.
	b)	41 (82.7)	15 (49 ft. 2 1/2 in.)	—
	b)	37 (74.6)	12.15 (39 ft. 10 3/8 in.)	—
	b)	33.4 (67.3)	12 (39 ft. 4 1/2 in.)	—
<b>Luxemburg.</b> <i>Prince Henri Railways and Mines.</i>	a)	46.2 (93.1)	18.12	...
	a)	38.5 (77.6)	(59 ft. 5 1/2 in.)	...
The secondary lines are provided with used rails.				
<b>Norway.</b> <i>State Railways.</i>	a)	49 (98.8)	15 (49 ft. 2 1/2 in.)	Joints on two sleepers, connected together.
	a)	41 (82.7), 40 (80.6), 35 (70.6)	15 (49 ft. 2 1/2 in.), 12 (39 ft. 4 1/2 in.)	...
	b)	30 (60.5), 25 (50.4)	7.5 (24 ft. 7 1/4 in.) 10 (32 ft. 9 3/4 in.)	...
	a)	45 (90.7)	12 (39 ft. 4 1/2 in.)	Joints on two sleepers, connected together.
<b>Rumania.</b> <i>State Railways.</i>	a)	45 (90.7)	12 (39 ft. 4 1/2 in.)	Joints on two sleepers, connected together.
	b)	34.5 (69.5)	Rails removed from the main lines are used.	...
<b>Yugoslavia.</b> <i>State Railways.</i>	a)	45.2 (91.1)	15 (49 ft. 2 1/2 in.)	Firm joints on sleepers; double; suspended.
	b)	35.6 (71.8)	15 (49 ft. 2 1/2 in.)	...
	b)	26.1 (52.6)	12.5 (41 feet)	Suspended.

## The second part of the questionnaire.

in lines; b) Secondary lines?

Number and kind of sleepers.	Method of fixing the rails to the sleepers.	Type of ballast.
or 15 metres, wood or metal.	Sole plates, clips and coach screws — clips and bolts.	River gravel, broken stone.
and 20, wood.		
wood.	Sole plates, clips — sole plates, clips and coach screws.	
or 15 metres.	Sole plates, coach screws and clips.	Granite chippings.
or 25 for 15 metres, of pine.		
or 12 metres.	Coach screws and clips.	Gravel.
or 10 of pine.		
or 19 for 12 m., wood or metal.	Plates, coach screws, bolts.	Pebbles mixed with sand.
or 19 for 12 m.		
or 19 for 12 m.	Plates, coach screws.	...
or 13 for 8 m., wood or metal.		
0 per km. (2 414 per mile), wood.	Clips.	Coarse gravel.
...	...	...
y 0.75 m. (2 ft. 5 1/2 in.), one oak sleeper.	Coach screws.	Pebbles.
or 30 for 18 metres, wood or metal.	Wood sole plates, coach screws, clips and bolts.	River gravel, broken stone, slag.
and 24		
-20 } wood.	Hooked sole plates, clips and coach screws.	
-17 }		
or 18 m., oak.	Poplar packings, with coach screws, steel plates with clips.	Broken slag.
or 12 m., oak.		
or 12 m., oak.		
lined from the main lines.		
or 15 m., wood.	Sole plates with coach screws, hook bolts, clips.	Gravel and broken stone.
0 per km. (1 931 per mile).	Sole plate with clips.	
or 12 m., wood, and 2 joint sleepers.	Plates, coach screws.	Broken stone, gravel.
...	...	Gravel mixed with sand.
or 15 m., and 2 joint sleepers, wood.	Coach screws, spikes.	Broken stone or gravel.
and 19 for 15 m.		
and 17 for 12.5 m.	Spikes.	River gravel.

NAME OF ADMINISTRATION.		What is your most recent pattern of tra		
		Weight of rails in kgr. per m. (in lb. per yard).	Length of rails in metres (in feet and inches).	System of joints.
<b>Sweden.</b> <i>State Railways.</i>	a) { b) {	43.2 (87.1) 41.2 (83.1) 34.5 (69.5) 27.6 (55.6)	... ... ... ...	Supported and suspended joints.
<b>Sweden.</b> <i>Göteborg-Boras Railways.</i>	a) { b) {	41.2 (83.1) 32 (64.5) ... ...	12 (39 ft. 4 1/2 in.) 10 (32 ft. 9 3/4 in.) ... ...	... ...
<b>Sweden.</b> <i>Nora-Bergslagen Railways.</i>	a) { b) {	32.7 (65.9) 23.0 (46.4)	12 (39 ft. 4 1/2 in.) 9 (29 ft. 6 3/8 in.)	Suspended joints.
<b>Sweden.</b> <i>Stockholm-Roslag Railways.</i>	a) { b) {	22.8 (46.0) 32.7 (67.9) ... ...	10 (32 ft. 9 3/4 in.) ... ... ...	Suspended joints. ...
<b>Sweden.</b> <i>Västergötland-Göteborg.</i>	a) { b) {	24.8 (50.0) ... ...	10 (32 ft. 9 3/4 in.) ... ...	Not stated. ...
<b>Switzerland.</b> <i>Federal Railways.</i>	a) { b) {	46 (92.7) ... ...	18 (59 ft. 5/8 in.) ... ...	Supported joints. Used material from
<b>Switzerland.</b> <i>Bernese Alps Railways.</i>			See under Swiss Federal Railways.	
<b>Switzerland.</b> <i>Rhætian Railways.</i>		25 (50.4), 27 (54.4), 30 (60.5)	12 and 15	Suspended joints.
<b>Czechoslovakia.</b> <i>State Railways.</i>	a) { b) {	49.7 (100.2) 44.4 (88.5) 47.1 (94.9) (*) 35.6 (71.8) Used material 26.1 (52.6)	25 (82 ft. 1/4 in.) 20 (65 ft. 7 3/8 in.) 15 (49 ft. 2 1/2 in.) 15 (49 ft. 2 1/2 in.) 15 (49 ft. 2 1/2 in.) from the main line tracks is employed and also: 12.5 (41 feet)	Bridge joints. ... Suspended joints.
(*) In tunnels.				

Main lines; b) Secondary lines?

Number and kind of sleepers.	Method of fixing the rails to the sleepers.	Type of ballast.
wood.	Plates, spikes.	Gravel.
wood.	Spikes or rail chairs with bolts.	Gravel.
...	...	...
wood,	Spikes.	Gravel.
not stated.	Spikes.	Gravel or pebbles mixed with sand.
to 13 per 10 m.	...	...
...	Spikes.	Gravel.
100 per km. (2 414 per mile), wood.	...	...
for 18 m., wood and steel.	Sole plate with coach screws, clips and bolts.	Broken stone.
Main lines is employed.	...	River gravel.
steel or wood (in tunnels).	Clips with bolts, plates with spikes.	Broken stone.
— 38 for 25 m.	...	...
— 23 for 15 m.	Plates, coach screws, clips, spikes, chairs (in the tunnels).	Broken stone.
— 23 for 15 m., wood.	Plates, spikes.	Broken stone, gravel, sand.
to 18 for 12.5 m.		

## Replies received to the 4th, 5th, 6th and 7th question

NAME OF ADMINISTRATION.	Question 4.	
	Average length of line kept in repair by a gang.	
	Number of platelayers including the foreman platelayer, and if there are any, his assistant and under-foremen.	
	Main lines.	Secondary lines.
<b>Bulgaria.</b> <i>State Railways.</i>	10 km. (6.2 miles) with 6 permanent workmen, and 6 temporary workmen.	
<b>Denmark.</b> <i>State Railways.</i>	6 to 10 km. (3.7 to 6.2 miles) with 4 to 5 employees and a certain number of day labourers.	
<b>Egypt.</b> <i>State Railways.</i>	About 5 km. (3.1 miles) of double track; about 8 km (5 miles) of single track. A gang consists of a foreman platelayer, a senior platelayer, and 6 to 8 platelayers.	
<b>Finland.</b> <i>State Railways.</i>	There are no gangs (See under 1 A a).	
<b>Greece.</b> <i>North-West Railways.</i>	...	One foreman, one under-foreman and 4 workmen.
<b>Luxemburg.</b> <i>Guillaume-Luxemburg Railways.</i>	12 km. (7.5 miles) double track; 7.5 km. (4.7 miles) single track. The number of platelayers in a gang (including foremen and under-foremen as permanent employees, varies from 17 to 30 for the gangs in large stations. From 10 to 19 for gangs on sections of open line.	
<b>Luxemburg.</b> <i>Prince Henri Railways.</i>	In ordinary track, a gang should have 10 to 12 men.	4 to 6 km. (2.5 to 3.7 miles) of track 5 to 6 men.

## the second part of the questionnaire.

Question 5.	Question 6.	Question 7.
<p>Formula for determining the number of workmen necessary for the maintenance of a certain length of track.</p>	<p>Is the number of workmen in a gang constant winter and summer, or do you have gangs formed of a limited number of workmen, who are permanent employees of your administration, supplemented in summer by temporary workmen?</p>	<p>What other duties are allotted to the gangs, such as : cleaning ditches, keeping hedges in repair, etc., or is such work entrusted to contractors?</p>
<p>No.</p>	<p>No. In winter, 6 men. In summer, each gang is made up of 15 men.</p>	<p>On maintenance work alone. The other work is done by a special set of employees.</p>
<p>The number of workmen is fixed according to the number of axes running annually over the track. It is fixed at 0.2 to 0.6 man per km. (0.32 to 0.96 per mile) of track, with any necessary additions.</p>	<p>The number of employees is fixed. A certain number of day labourers is added thereto, according to the season and by calculation,</p>	<p>The gangs do all the maintenance work, etc., on the track. Maintenance work is not entrusted to contractors.</p>
<p>1 km. of double track = 1.5 km. } 1 km. of sidings track = 0.5 km. } of single track. switch = 0.1 km. (0.062 mile). } 36 man is employed per km. (1.38 men per mile) of single track.</p>	<p>The number is constant.</p>	<p>There are no ditches nor hedges along our railways.</p>
<p>No.</p>	<p>No.</p>	<p>No permanent gangs or contractors.</p>
<p>No.</p>	<p>The number is constant. In spring we engage day labourers for weeding.</p>	<p>The gangs are also employed on cleaning the ditches.</p>
<p>or 1 km. (1 mile) of single track, 0.66 (1.06) men. or 1 km. (1 mile) of double track, 1.00 (1.6) men. or 1 km. (1 mile) of triple track line . . . . . 1.66 (2.67) men. or 1 km. (1 mile) of four-track line . . . . . 2.00 (3.2) men. or 1 km. (1 mile) of goods track . 0.3 (0.48) man. or 60 units of apparatus . . . 1.0 man. platelayers per district for the maintenance of safety plant and for the relief of employees who are sick or on leave.</p>	<p>The gangs are formed of a certain number of permanent employees, reinforced during the good season by day labourers.</p>	<p>The gangs have to do all the maintenance work, and clean the track, ditches, hedges, etc.</p>
<p>switches count only 1/2, and sidings tracks only 1/4 of the length of open line. platelayer per 1.450 km. (0.90 mile) of main line. platelayer per 1.750 to 2.0 km. (1.08 to 1.24 miles) of secondary line.</p>	<p>The number of workmen is the same, winter and summer. It is only exceptionally that temporary workmen are engaged.</p>	<p>Other occupations of the gang: maintenance of hedges, ditches, culverts, etc., assisting in the maintenance of telegraph lines under the supervision of special telegraph employees.</p>

NAME  OF  ADMINISTRATION.	Question 4.	
	Average length of line kept in repair by a gang.	
	Number of platelayers including the foreman platelayer, and if there are any, his assistant and under-foreman.	
	Main lines.	Secondary lines.
Norway. State Railways.	See Question I A.	
Rumania. State Railways.	7 to 9 km. (4.35 to 5.6 miles). Each gang is formed of 9	9 to 15 km. (5.6 to 9.3 miles). workmen with a foreman.
Yugoslavia. State Railways.	4 km. (2.5 miles). Each gang is composed of 8 to 11 platelayers, including the foreman-platlayer.	8 km. (5 miles).
Sweden. State Railways.	The gangs are not generally employed on maintenance work; only straightening the track. One foreman and about 6 men.	
Sweden. Göteborg-Boras Railways.	For ordinary maintenance, the men work in pairs on heavy traffic line. One extra workman (apart from the ordinary platelayer) is allowed for every 5 km. (3.1 miles) of track with little traffic, and two extra workmen for every 5 km. (3.1 miles) of track with heavy traffic.	
Sweden. Nora-Bergslagen.	4 km. (2.5 miles); 1 foreman and 4 workmen.	
Sweden. Stockholm-Roslag.	5 to 7 km. (3.1 to 4.35 miles). 3 men.	2 men.
Switzerland. Federal Railways.	About 14 kilometres. 12 to 20 employees.	
Switzerland. Rhätian Railways.	About 20 km. (12.4 miles). Permanent gangs of 10 men for maintenance work.	
Czechoslovakia. State Railways.	5 to 10 km. (3.1 to 6.2 miles). Each gang numbers 9 to 11 men, including the foreman platelayer, and a number of workmen necessary for maintenance work, for relieving watermen and for assisting in other services.	10 to 15 km. (6.2 to 9.3 miles).

APPENDIX III (continued)

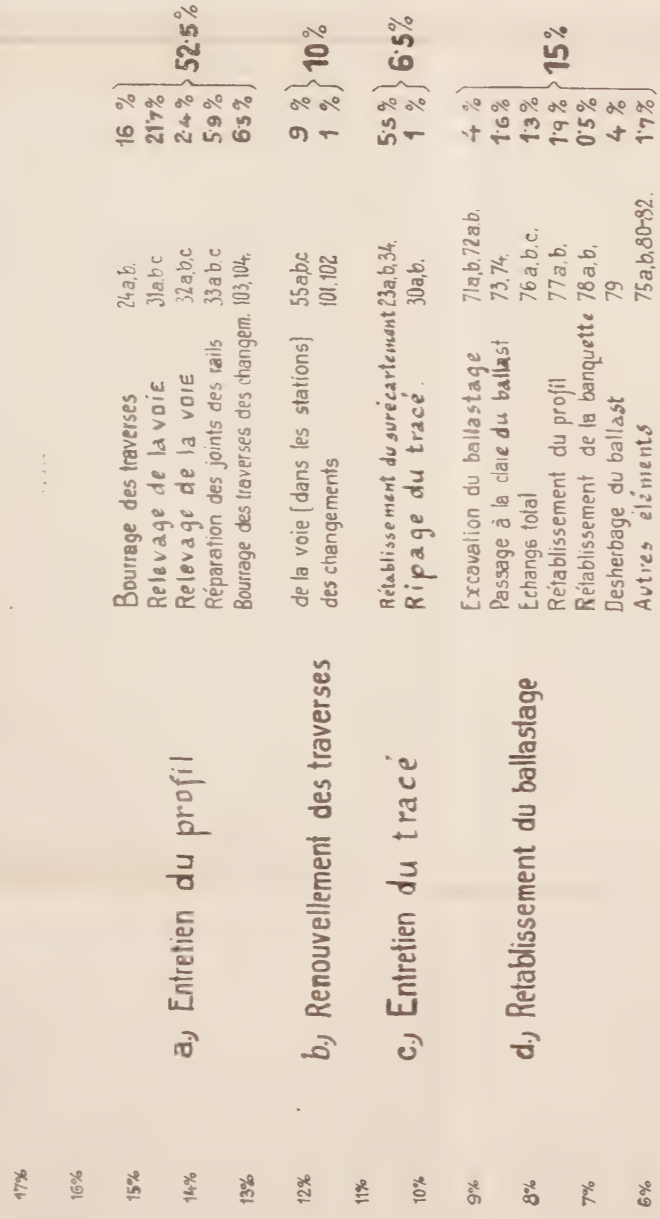
Question 5.	Question 6.	Question 7.
<p>rule for determining the number of workmen necessary for the maintenance of a certain length of track.</p>	<p>Is the number of workmen in a gang constant winter and summer, or do you have gangs formed of a limited number of workmen, who are permanent employees of your administration, supplemented in summer by temporary workmen?</p>	<p>What other duties are allotted to the gangs, such as : cleaning ditches, keeping hedges in repair, etc., or is such work entrusted to contractors?</p>
<p>No.</p> <p>men per km. (1.9 per mile) of single track (main lines).</p> <p>men per km. (1.6 per mile) of single track (secondary lines).</p> <p>men per km. (1.3 per mile) of station track.</p> <p>men for 20 switches.</p>	<p>To assist the foremen and line watchmen, mentioned under I A, temporary workmen are employed in summer and partly in winter.</p> <p>The number of workmen is constant winter and summer; temporary workmen are added for unforeseen work.</p>	<p>This work is done by the same employees stated under the heading 6.</p> <p>The gangs have to do all the maintenance work on the track, such as cleaning ditches, repairing hedges, etc.</p>
<p>No.</p>	<p>Each gang numbers 4 to 6 permanent employees of the Administration.</p> <p>This number is made up in the springtime by day labourers.</p>	<p>The work referred to is done by the maintenance gangs.</p>
<p>No.</p>	<p>See Question 4.</p>	<p>See Question 4.</p>
<p>No.</p>	<p>See Question 4.</p>	<p>See Question 4.</p>
<p>No.</p>	<p>Each gang is made up in summer by day labourers.</p>	<p>The work referred to is done by maintenance gangs.</p>
<p>No.</p>	<p>The number of workmen is constant summer and winter.</p>	<p>The work referred to is done by maintenance gangs.</p>
<p>No.</p>	<p>During the good season, the gang is completed by temporary workmen.</p>	<p>This work is done by our own employees during the winter season.</p>
<p>No.</p>	<p>Number of workmen is constant.</p>	<p>In exceptional cases, this work is entrusted to contractors.</p>
<p>1. of main line double track = 1.75 1. of sidings track = 0.33 km. 1. of secondary line single track = 0.75 switches 1.00 (0.62 mile).</p>	<p>Each gang numbers about 6 to 8 permanent employees, the gang being made up by day labourers in spring and summer.</p>	<p>The work referred to is done by maintenance gangs.</p>



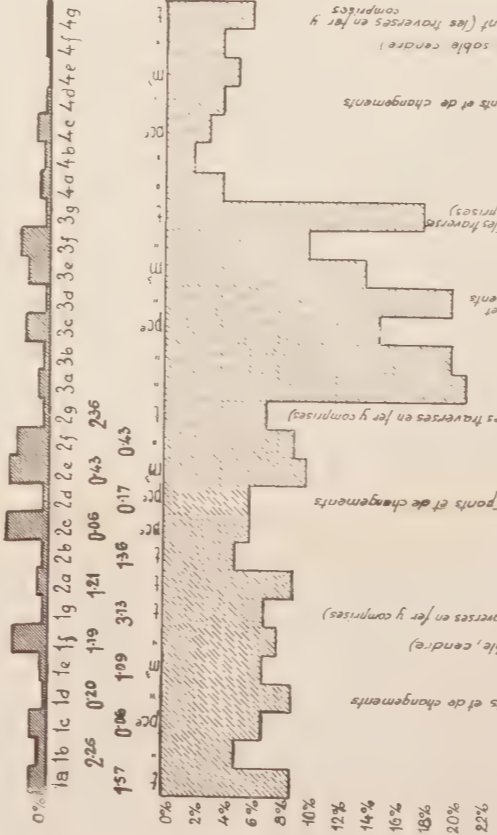
1. *North of 40° 45' N.*

Representation of the word "the" in the total word "the" to a number to 1927. Note on the left the direct values of the word "the" in the Slovakian, Czech, and Russian languages. On the right, the corresponding values of the word "the" in the English language. All Div

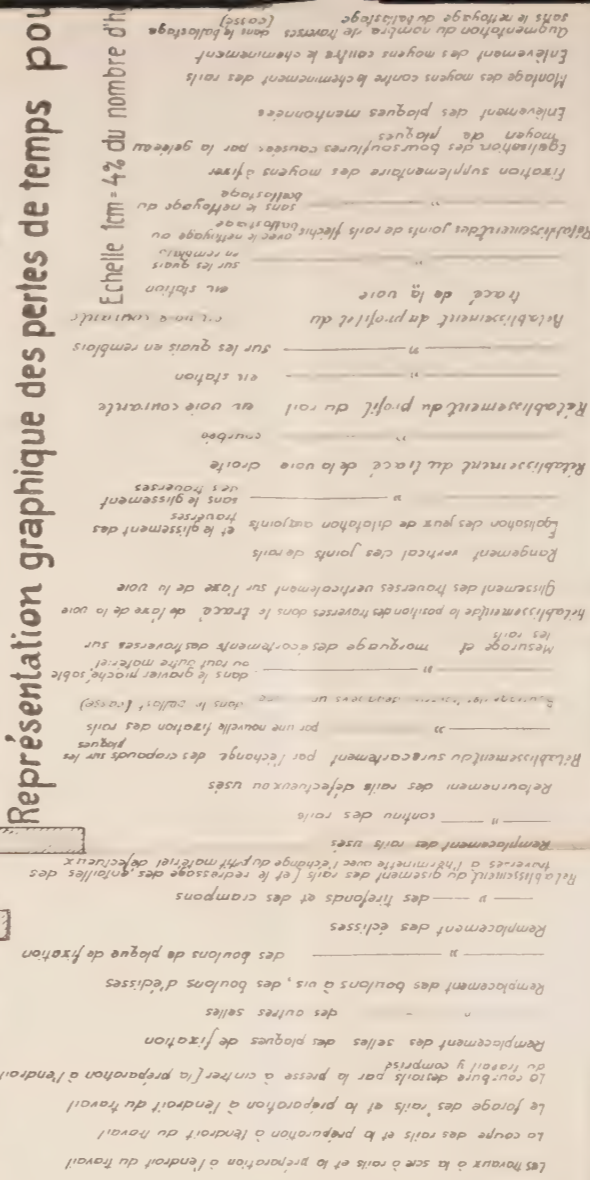
Toutes les directions des chemins de fer de l'Etat tchécoslovaque



**A** Les travaux concernant le matériel même pour l'entretien de la superstructure.



### Représentation graphique des pertes de temps pour



## Description des détails des opérations

Description of details  
of the operations.



## REPORT No. 4

(Germany)

ON THE QUESTION OF RECENT IMPROVEMENTS IN PERMANENT WAY TOOLS AND IN THE SCIENTIFIC ORGANISATION OF MAINTENANCE WORK (SUBJECT IV FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) <sup>(1)</sup>,

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Reichsbahndirektor and Member of the Headquarters Administration of the Deutsche Reichsbahn Gesellschaft  
(German State Railway Company).

Figs. 1 to 33, pp. 1084 to 1145.

The questions under examination, namely :

*Recent improvements in permanent way tools and in the scientific organisation of maintenance work* have been dealt with in this order in accordance with the Questionnaire submitted. It has nevertheless been necessary, on account of the great field which the subject in question covers, to refrain from describing in close

detail the apparatus and methods of operation etc., and from dealing with the economy of each. The description has rather been limited to important points in each case, and in order to make the subject more intelligible where it seemed advisable, it has been amplified by photographs, so that a comprehensive and continuous picture of the subject can be obtained.

*The contents are as follows :*

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<sup>(1)</sup> Translated from the German.

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#### A. — Progress in the utilisation of mechanical appliances for track maintenance.

##### 1. — General.

Ever since the beginning of railways, all executive departments have gone into the question of making the permanent way as safe and as efficient as possible; but until a few years ago no material alterations or improvements had been made in working methods or appliances. This long period of stagnation starting almost from the beginning of railway construction, appears difficult to understand when one considers that experience in doing work by machinery instead of by hand was being gained with an ever increasing degree of success in other constructional undertakings. When one considered, however, the amount of materials in comparison with the man power required, a definite stimulus was given in permanent way operations for speeding up the work and for the promotion of efficiency by using machinery and mechanical tools whenever possible. There must have been some special reasons why these improvements had

been developed so comparatively late in the day and even then in such a hesitating manner.

Generally speaking they were the exacting demands which had to be made on the machines and tools and which were difficult to meet at the stage of development which engineering had reached at that time.

It is not a question, as in workshops, of stationary machines to which the work is brought, or as in the case of constructional and other building work, of machines which for weeks and months can remain in one place, and in most cases can be erected under shelter, but of machines which follow the continually moving work on the permanent way, and therefore move their position at more or less short intervals during the day's work. They must therefore be portable. In addition the dimensions of the machines must be kept within the limits necessary to prevent delays or danger to traffic which in the first case are decided by the limits of the loading gauge and in other cases by the usually small space available outside the track. In spite of this limit in the dimensions, the machine has to be efficient and as foolproof as

possible, since it is at the mercy of the wind and weather on the track, and is usually placed in the hands of unskilled workmen. It was only gradually that it became possible with the development of the internal combustion engine to obtain a portable power source which delivered a large amount of power with the minimum weight and space requirements and yet was so simple and foolproof that it could be easily looked after by unskilled workmen.

Against the introduction of machines, certain doubts of an economic nature arose. It was thought that the machines on account of the frequent interruption of their working owing to the traffic on the lines and on account of their lying idle during the winter, could not be economically worked and therefore could not show any advantage. The economical results of the work of these machines have, however, shown that this fear was groundless. In addition the advantage has been shown that the work can be better carried out by machines during the available intervals, which are always becoming less frequent and shorter owing to the ever increasing traffic, and therefore in the interests of traffic operation the work can be more quickly completed.

It must be mentioned here that it is not every kind of manual work which can be carried out by machinery with economic success. For a large amount of track construction and maintenance work a certain number of workmen is necessary on account of the kind of work which has to be dealt with and the weights of the materials which have to be moved, and their complete employment during single operations of the work would be influenced by the use of machines. It must therefore be considered carefully whether

the machines actually help the work along in an economic sense or whether they can be better dispensed with. It is just at the present time when all kinds of machines are available that this examination is necessary.

An objection which is indeed not entirely without foundation was raised from an operating standpoint against the use of certain machines, *viz.*, against those which are able to move on the rails under their own power and further those which occasion a great amount of noise.

It is obvious that attention must be paid as far as possible to the legitimate wishes of the operating department. For machines which can move under their own power form a source of danger which must be considered especially on tracks where the traffic is dense. The wishes of the permanent way engineer must give way in these cases to the necessities of traffic operation. Apart from rail motor cars, motor line inspection trolleys and motor trolleys, the use of which for the purpose of conveying men and materials on the track is unavoidable, the question of the movement of machines on the tracks under their own power, such as track laying apparatus, ballast motor rollers, etc., as well as the use of tractors for hauling a few trucks, must be considered most carefully. The idea of using the source of power which is available for the work the machine has to do, to move the machine itself is interesting in itself; in the majority of cases, however, it will be necessary to do without this to suit the requirements of the operating department.

Then care must also be given to seeing that the machine can be operated as far as possible upon the track on which it is working so that a neighbouring run-

ning track is not made use of even if only periodically, and therefore has to be closed.

A further source of continual trouble is occasioned by the noises which cannot be avoided in tracklaying appliances with internal combustion engines and which already in many cases have been the cause of accidents and loss of life. All attempts effectively to damp these noises by suitable appliances have not led so far to any satisfactory result. Therefore for that class of work for which such power engines are used, special safety precautions have to be taken which consist chiefly in an increase of look-out men and the equipment of these with audible signals of great volume and characteristic tone. Naturally the economic advantage of the machines is somewhat influenced by this so that the question of replacing internal combustion engines by a different and silent driving power, *i. e.* electricity, must be followed up further.

The fears that were at first raised that the workmen would sabotage the machines, first from the generally existing objection of workmen to any novelty, and second, from the fear of dismissals, have fortunately not materialised in actual practice. The workmen, on the contrary, have recognised that the machines make the work easier for them, and have therefore taken kindly to them.

Summing up, it can be said that machines, for laying as well as for the maintenance of the track, can be used in many instances with good economic results, and that they speed up the work. A primary condition for this is that they should be introduced in a correct and regular manner, *i. e.* that according to the type of work and with regard to the

traffic condition, as large a use as possible should be found for the machines, and that in addition, considerable intervals of idleness when going from one to another job should be avoided.

For this purpose a programme is made up for the machines as early as possible and the observance of the programme supervised. Those machines and recent appliances which are used and the economic results which are obtained by them are shown below separately.

## 2. — Operations where mechanical appliances can be used.

The attempt to mechanise work on the tracks dates back to the time before the war; and it was tamping which, on account of its heavy demand on man power, brought up the idea of using mechanical tamping tools for the purpose. Tamping is responsible for about 70 %—80 % of the work which has to be carried out on track maintenance but it was only after the war that the idea of using track tamping machines and other mechanical auxiliaries for the construction and maintenance of the tracks was taken up again with great energy and developed further, because the necessities of the time made it imperative to reduce expenditure as far as possible by making use of all mechanical appliances and thereby carrying out the work more economically. The type and number of machines and recent appliances which are now being used, and the date of their introduction can be seen from Appendix I. We use these devices for the following purposes :

a) Motor driven rollers for consolidating the formation;

b) Self discharging ballast wagons for the conveyance of ballasting materials from their source of manufacture to their

place of use. The ballasting materials can be discharged at the right place in the desired quantities;

c) Rail loading appliances for loading up and unloading rails;

d) Ballast rollers as under a) for compressing the ballast, as well as ballast boxes for the formation of sleeper beds for steel sleepers. The consolidation of the ballast is, however still carried out by hand by the use of simple tamping tools when the traffic does not allow the closing of a track for too great a distance, and further, when replacing crossings and for all small jobs for which the use of a ballast roller would not be economical;

e) Track laying apparatus for conveying and taking up complete sections of track and switch laying apparatus;

f) Motor trolleys and single rail trolleys for the conveyance of materials along the track for small distances;

g) Electric sleeper boring machines for boring wooden sleepers, which are connected to a portable electric power source. The majority of wooden sleepers are planed and bored, in more recent times, in the sleeper impregnation works before impregnation;

h) Electric screwing machines which are connected to portable power sources for tightening up coachscrews on the track. On the new German permanent way the soleplates are screwed by machine on to the wooden sleepers in the sleeper impregnation works immediately after impregnation and the coachscrews only need to be tightened up on the track;

i) Mechanical fishbolt spanners for tightening up fishbolts by hand. The remaining coachscrews are tightened up as mentioned in h) by screwing machines;

k) The regulation cross section of ballast is formed by hand with templates and the necessary ballasting materials are brought up in self-discharging wagons;

l) Rail winches for lifting up the track to the right height, which is fixed by bench marks. The lining of the track is done in the same way according to such bench marks but by hand by aligning the track with lining bars;

m) Track tamping machines;

n) Spraying trains, with tanks, for killing weeds growing in the ballast and across the whole breadth of the formation. The cleaning of the ballast for the purpose of making it more elastic and better able to get rid of water is at the present still done by hand. For some time, however, attempts have been made to do this work by machinery also; conclusive results, are not yet available;

o) Electrically driven rail saws and rail drilling machines for cutting and drilling the rails; these are connected to portable electric power sources. As a rule, rails are not bent on the German Railways; therefore rail bending machines, of a very simple type, are found only to a small extent;

p) As special means for the transport of materials, only the self-discharging ballast wagons mentioned under b) are used. For the transport of rails, sleepers, rail fastenings, etc., ordinary wagons are used;

q) Portable electric power units, which consist of a dynamo coupled to an internal combustion engine, which are used as a power source for all kinds of electrically driven machines, such as coach-



Fig. 1. — Motor roller rolling down freshly laid ballast.

Explanation of German terms: Motorwalze = Motor roller. — Frischgeschütteter Bettungskörper = Freshly laid ballast.

screw tightening and loosening machines, rail and sleeper boring machines, rail sawing machines, etc. The power unit can also be used during night work for electrically illuminating the site;

r) Heavy rail motor cars (motor line inspection trolleys) for the inspection of the track by the divisional permanent way superintendent of the railway and ordinary motor line inspection trolleys for the other inspectors. Some motor line inspection trolleys are so equipped that they can be used as power sources for electric lighting;

s) Permanent way testing car for close inspection of the track. The line is regularly gone over with this car; by means of certain ingeniously fitted apparatus it is possible graphically to indicate on a moving band the vertical and horizontal deflections of the rails under a moving load.

### 3. — Description of the appliances.

a) For rolling the formation and in particular in cases of freshly tipped earthwork, and for consolidating the formation, tandem or three-wheeled motor rollers of various types are used. They have a weight in working order of 5 to 6 tons, which can be increased by means of an additional weight, by 1 ton. The motor is at least 12 H.P. Benzol or crude oil is used as fuel. The fuel container is of sufficient capacity for 9 hours work. Its speed is 2 1/2 and 6 km. (1.55 and 3.7 miles) per hour. The greatest width of the roller amounts in the tandem to 1.10 m. (3 ft. 7 5/16 in.) and in the case of the three-wheeled roller to 1.75 m. (5 ft. 8 29/32 in.). Figure 1 shows a tandem motor roller rolling a freshly tipped ballast formation. Figures 2a and 2b show a roller transportation car for the transport of rollers to and



Fig. 2a. — Roller transportation wagon showing end opened.



Fig. 2b. — Roller transportation wagon showing end (used as a ramp).

from the site. Figures 3a and 3b show a three-wheeled motor roller which can run on the track to the site under its own power. There, the flange wheels are

taken off by means of the ramp which can be seen in the picture, and are subsequently fitted again.

When ballast and track have to be



Fig. 3a. — Three-wheeled motor roller. — Flange wheels being removed.



Fig. 3b. — Three-wheeled motor roller. — Flange wheels being refixed.

renewed at the same time, which is now the custom, the ballast must be effectively consolidated before the permanent way is laid. By this means the newly laid track receives a firm foundation from the beginning, so that sinking of the permanent way, and other disadvantages which otherwise occur with freshly laid ballast, are avoided.

After removal of the old ballast, the formation is levelled to the correct angle, by the use of templates and guiding pegs. The formation or bottom ballast is then so thoroughly rolled that no further appreciable sinking takes place.

The ballasting material (broken stone) is rolled in two or three layers of 12 to 16 cm. (4 3/4 to 6 5/16 inches) thickness each, according to the required depth of ballast. The broken stone must not be damaged during rolling. The elasticity necessary for the protection of the permanent way has been found by experience to be best maintained when the ballast is compressed by 20 %.

b) For the transport of ballasting materials from their source of manufacture or origin to the site, and for their correct distribution on the spot, self-discharging ballast wagons are being used in increasing numbers. Their design and use can be seen from figures 4a-4c. The load of the wagons is 20 tons and their capacity is 12.5 m<sup>3</sup> (16.3 cubic yards). The wagons are formed into permanent trains which continually travel from the loading to the discharging points at the smallest possible intervals. The use of single wagons is not economical.

Besides these, tip wagons are used for the transport of earth and spent ballasting materials, which can also be used for new ballast materials. Their design and use can be seen from figures 5a and 5b.

c) The design and method of operation of rail loading apparatus, which is recently being generally introduced, can be seen from figures 6a and 6c. We attach much importance to the careful handling of the rails, and above all that they are not thrown off, thus avoiding short kinks in the rails which can never be removed.

The appliance differs from previous designs particularly in its low weight. It makes possible the loading and unloading of rails not only on the site of operations, but also on the open track without interfering with operations on the neighbouring track. Rails of any desired length and also, in particular, rails longer than standard can be unloaded with a comparatively small number of workmen. For rails of 30-m. (98 ft. 5 in.) length, 3 or 4 such appliances are necessary, each of which is worked by two men.

The appliance can be fitted on to the rail wagon by 4 workmen in a few minutes. For relieving the strain on the supporting structure the crane standard is firmly anchored to the wagon by means of a special chain. The rails can be moved sideways to and fro as desired when being loaded or unloaded from the wagon by means of a travelling crab, so that hand work on the rail wagon is practically nil.

d) The permanent way for steel sleepers is laid with the help of ballast boxes, as a matter of principle. These serve the purpose of so arranging the ballast mould for each steel sleeper that when the latter is laid on, its hollow part is completely filled and that the sleeper in addition lies correctly both vertically and horizontally and so that only a small amount of tamping and other work is necessary. This naturally makes it essential that



Fig. 4a. — Self-discharging ballast wagons. — Loaded ballast train.



Fig. 4b. — Self-discharging ballast wagons. — Upper shoot opened.

the preliminary work for the use of the ballast boxes is carried out very accurately.

As carriers for the ballast boxes and for the purpose of fixing their exact posi-

tion, the new rails to be laid are used in the first place as guiding rails. These rails are placed on each side of the track to be laid, on jacks which can be moved vertically and horizontally and which



Fig. 4c. — Self-discharging ballast wagons. — Lower shoot opened.



Fig. 5a. — Loaded tipping wagons.



Fig. 5b. — Tipping wagon in the tipped position.

are exactly adjusted for vertical and horizontal positions as shown in figures 7a and 7b. Then the ballast boxes are placed on the final position for the sleeper which is indicated on the guiding rails by paint marks, and are then filled with ballast which is firmly tamped lengthways by hand, as shown in figures 7c and 7d.

Ballast boxes are also used in a similar manner for the laying of switch and crossing work on steel sleepers. Figure 8 shows such a process of switches and crossings.

c) For track renewals there is available a number of track laying apparatus of different types, of which the method of operation, taken generally, is the same and with which complete sections of rails can be taken up and loaded on to wagons and vice versa.

The simplest type of such a track laying device, and the one originally intro-

duced is a slewing crane made by the firm Mohr and Federhaff of Mannheim. The design and method of operation of this can be seen from figures 9a and 9b. In this case the section of rail is held in several places by means of a frame in order to prevent bending. The same crane is used also for unloading the rails. The disadvantage of this slewing crane lies in the fact that a neighbouring track must also be in use and therefore is closed during relaying operations. In this manner therefore the first principle given at the commencement of this report is contravened, namely that when a machine is used both the tracks of a double track must not be closed for traffic. Apart from that, there is a liability of the crane in slewing to foul the loading gauge; for this reason, only three cranes of this type have been procured. Appendix 2 shows diagrammatically the possibilities of the use of this crane.



Fig. 6a. — Rail unloading device.  
Fixing the jib.



Fig. 6b. — Rail unloading device.  
Fixing the crane standard on to the wagon.



Fig 6c. — Rail unloading device in operation.



Fig. 7a. — Adjusting guide rails for height.



Fig. 7c. — Tamping the sleeper moulds.



Fig. 7d. — Laying the steel sleepers.

Fig. 7b. — Lining up the guide rails.



Fig. 8. — Use of ballast boxes when laying switches.

In order to overcome the above mentioned disadvantages the Reichsbahn has proceeded to introduce other track laying devices which make the use of the adjoining track unnecessary and only use the track on which work has to be done. They also offer the certainty of keeping within gauge except on very sharp curves. These are the track laying wagons of the Hoch and Niomag types which are shown in figures 10a-10b and 11a to 11c, the methods of working and diagrams of which are set out in Appendix 3.

These wagons consist of the underframe, upper carriage or superstructure, the trolley way and the driving apparatus.

The underframe consists of standard wagons with two or three axles on which the gantries are built which carry the trolley way.

In the Hoch track laying wagon, the trolley way projects in the working position at one end so far over the upper structure that the section of rail can be picked up by both ends by means

of rail grabs which hang on two pulley blocks. The wagon can therefore only be used at one end. A part of the runway can be folded back and is supported by a movable frame. When travelling the runway is folded back and the frame is drawn back to the upper structure and fastened to it.

The Niomag track laying wagon is symmetrical in design so that it can be used at both ends. The runway can be moved at both ends over the upper structure so that the section of rail can be gripped in the middle by means of a so called track section grab similar to the one used on the slewing crane built by Mohr and Federhaff. By this means also the lifting of the section of rail from the track and loading on the wagon is considerably simplified and facilitated.

For lifting and moving the load on the Hoch track layer an electric drive is used which is driven by a petrol-electric unit slung under the wagon. With the Niomag machine, a horizontal single cylinder Diesel motor without compressor,



Fig. 9a. — Slewing crane, Mohr and Federhaff type.



Fig. 9b. — Unloading rails with the slewing crane.



Fig. 10a. — Hoch tracklayer at work.



Fig. 10b. — Hoch tracklayer. — Taking a section of track from the wagon.



Fig. 11a. — Niemag tracklayer at work.



Fig. 11b. — Niemag tracklayer. — Taking a section of track from the wagon.



Fig 11c. — Niemag tracklayer. — Laying down a section of track.

using gas oil is employed. The capacity in the former case 16 H. P. and in the later 28 to 30 H. P. The Niemag wagon can travel under its own power at speeds up to 9 km. (5.6 miles) per hour, and in addition, on straight level tracks can haul two trucks loaded with sections of rails.

Track laying cars are provided with specially equipped S. S. wagons which serve for receiving the new and old sections, and the number of which is calculated according to the extent of the work to be carried out. Devices are available which pull by machinery all the sections of rail loaded on to the wagon into the operating radius of the track layer and which conversely distribute sections lifted by the track layer into the wagons. Each wagon can be loaded with five sections of wooden sleepers and six sections of steel sleepers.

In all three methods the sections of track are assembled at special sites at a station

in the vicinity of the site of operations. They are loaded on to wagons and taken to the site. In a similar manner the old sections which have been loaded on to wagons are discharged at a suitable point in a neighbouring station or at the permanent way stores and are dismantled. This is done either with one track layer with which the old track is taken up and then the new track is subsequently laid, or better with two track layers of which one is used for the old track and the other for the new.

In addition to this process there has been tested since the year 1925 a so-called Neddermeyer track renewing method which should not remain unmentioned, on account of its simplicity and adaptability. The principle of this method is to raise and lay sections of track by means of two easily movable cranes on frames which run on light crane rails arranged along the track outside the sleepers. The frame of each crane is built to take a load

of 2.5 tons and has two independent lifting gears which are worked manually by windlass chains. The cranes take the form of sturdy frames: the load is taken vertically on the running rails. The possibility of the wheels slipping off the two rails is prevented by the provision of a double flange. The cranes are 2.80 m. (9 ft. 2 1/4 in.) high inside and have an inside width of 3.10 m. (10 ft. 2 in.). Of the two crane frames, the one on the side of the neighbouring track is bent at right angles so that in a double track line the necessary minimum measurement of 2 m. (6 ft. 6 3/4 in.) from the middle of the neighbouring track is ensured. The erection of the heavy crane frame which weighs about 1 ton is effected by means of a simple lifting gear which is fastened to the revolving platform of a lightly built wagon.

For the transport of sections of track small specially strongly constructed bogie wagons with a load capacity of 10 tons are used. For hauling the sections of track to the site a motor trolley of 45 H.P. is used. Details can be seen from figures 12a to 12d and the method of operation is diagrammatically shown on Appendix 4.

As in the case of the track laying devices already described, the track sections in this instance also are assembled or dismantled at special working sites in the neighbourhood. They are, however, conveyed on the last described special small wagon to and from the sites by the motor trolley. The advantage of this method lies in the fact that track sections up to a length of 60 m. (197 feet) can be laid even in curves without fouling the loading gauge, and that this method can also be used in tunnels and on bridges without any particular technical difficulty.

For facilitating the removal and laying of completely assembled switches and crossings a device has recently been experimented with, the type and method of operation of which is shown in figures 13a and 13b. It consists of a framework which is movable on rollers and from it the switch is suspended. As a matter of fact the renewing of switches and crossings occasions considerable difficulty at large stations on account of the, in most cases, short intervals and unfavourable positions available for the purpose. Means must therefore be provided of transporting complete lay-outs, only divided into 2 or 3 main parts, from the place of assembly to the site and vice versa. All the same, experience has shown that the switch laying devices described do not completely fulfil these demands. There will therefore be used in the future so-called portable switch laying cranes which are already under construction. At the moment nothing material can be said of their design.

f) The Reichsbahn has been testing motor trolleys for about two years. The small wagons with electric motors and accumulators have proved themselves satisfactory especially on account of their simple method of operation under certain conditions. All the same their small operating radius and the fact that the charging of the accumulator is dependent on the charging station, and their high tare weight, which make their running on the open track impossible, have led quite recently to tests being carried out with small trolleys with internal combustion engine. These tests have given favourable results. These trolleys reach, with a load of 3 to 5 tons on the level, a speed of 15 to 30 km. (9.3 to 18.6 miles, per hour. Figures 14a to 14c show a



Fig. 12a. — Relaying track by the Neddermeyer method. — Laying a 65 ft.-7 1/2 in. section of track using three cranes.



Fig. 12b. -- Relaying track by the Neddermeyer method.  
Laying a 49 ft.-2 1/2 in. section using two cranes.



Fig. 12c. — Relaying track by the Neddermeyer method.  
Tractor for hauling sections of track on special low wagons.



Fig. 12d. — Relaying track by the Neddermeyer method.  
Arrangement for removing the portal crane.



Fig. 13a. — Switch laying apparatus (side view).



Fig. 13b. — Switch laying apparatus (front view).



Fig. 14a. — Standard gauge motor driven trolley with internal combustion motor.  
View with sides fitted on.



Fig. 14b. — Standard gauge motor driven trolley. — View without sides fitted.

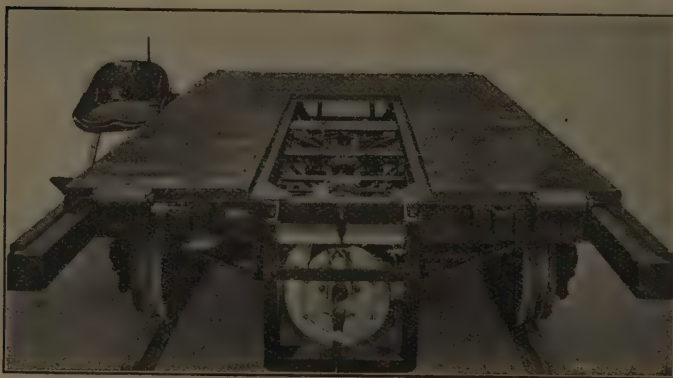


Fig. 14c. — Standard gauge motor driven trolley.  
Arrangement of the motor under the platform.

petrol-engined trolley of such a kind. The seat, gear lever and brake are removable and can be reversed according to the direction of travel.

For the transport of smaller quantities of material to the site of operation and within comparatively short distances along the track, single rail trolleys of the type shown in figures 15a and 15b are in use, and these have proved their worth because one man by himself can comfortably put the trolley on and off as well as move it.

Recently a device has been used experimentally for the removal of old ballasting materials taken from the track, which consists of an easily fixed single rail placed alongside the track, and which makes it possible by means of easily movable tubs which are hung on it, to load the old ballasting materials into wagons standing ready. For this purpose a tipping platform is erected on to which the tubs are drawn and where they can be emptied by opening flaps in the bottom. Figure 16a shows this single rail wagon with the tubs in operation. Figure 16b shows a tub running on the single rail, and figure 16c the tipping platform. Whether and where this arrangement can be used with economic success still remains to be proved. The idea in itself seems not to be without merit.

g) For power for all kinds of mechanical appliances, portable generating sets are used for permanent way work. These generating sets consist of internal combustion engines and direct current dynamos. Both are flexibly coupled and erected on a common foundation plate. The motor is a two cylinder 4-stroke with a capacity of 7 1/2 to 8 H. P. at 1500 revs. per minute; the electric current generator is a single-pole, direct

current, shunt-wound motor with a capacity of 2.2 to 4.5 kw. depending on the design. A generating set of this nature is shown in figure 17.

With these generating sets electric hand tools are connected up for performing work of the most varied nature, e. g. boring machines for boring wooden sleepers; figure 18 shows such a boring machine in operation.

The electrical part of the boring machine consists of a 2-pole series motor with which the flexible lead is joined by a 2-point plug contact. Three-strand cable is used for the lead. To protect the cable a portable cable drum is available for each length.

In addition machines for tightening and loosening coachscrews, sleeper fastening screws and fishbolts are connected up with these generating sets. These consists, as in the case of the previously mentioned sleeper boring machines as regards their electrical part, of a 2-pole shunt-wound motor with compound winding. The box spanners are made square and right angled to take the various shapes of head of the coachscrews and to take the various sleeper fastenings or fishing nuts. The special nature of the operation of tightening coachscrews as well as sleeper fastening nuts and fishing nuts renders it necessary to stop the screw turning machine when the coachscrews or nuts are turned absolutely tight. In order that the machine, at the moment when the coachscrew head or the nut tightens up solid, shall not be wrenched out of the hands of the operator and possibly injure him, protection has been given by a device — automatic circuit breaker or multi-plate clutch — so that the machine will be cut out on meeting a certain resistance. The method of leading the



Fig. 15a. — Single rail trolley in use.

current to the machine is the same as in the sleeper boring machine. Figures 19a and 19b show electric hand tools connect-

spanner can be seen from figures 20a and 20b.

b) For tamping the track, tamping machines are used to a considerable extent, and the type of these is shown in figure 21. The tamping machines of the 1929 model consist mainly of three parts: the machine unit, the tamping tools and the connecting pipes. The machine rests on a sledge which is laid on the tops of the sleepers outside the rails, and is drawn along by the workmen by means of chains fitted on the tamping machine. By designing it to lie on the tops of the sleepers, the machine therefore remains outside the loading gauge, so that it can remain where it is and run idle while a train passes. Only the tamping tools have to be laid down.

The method of operation of the track tamping machine can be seen from figures 22a to 22c. The parts which are connected together are indicated on the drawings. A valveless 2-stroke internal combustion engine controls, by means of



Fig. 15b. — Single rail trolley being tipped.

ed up to a generating set and used for various purposes.

The design of the mechanical fishbolt



Fig. 16a. — Single track railway with hanging trolleys in operation.



Fig. 16b. — Hanging trolley.



Fig. 16c. — Tipping platform of single track railway.

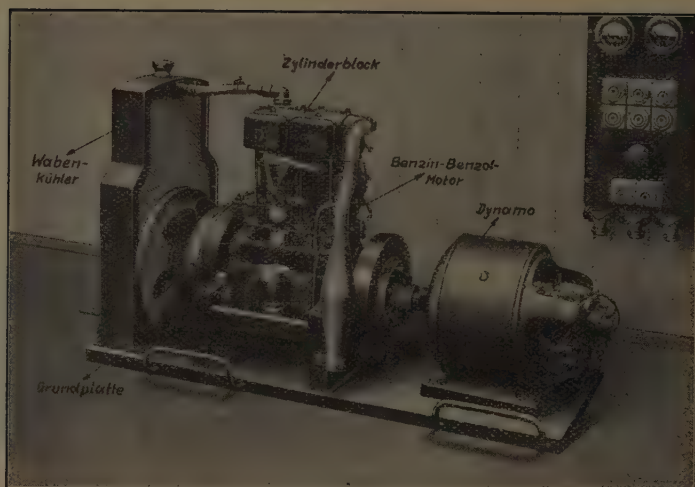


Fig. 17. — Portable generating set.  
(Internal combustion engine coupled to direct current dynamo.)

Explanation of German terms: Grundplatte = Baseplate, — Wabenkühler = Radiator.

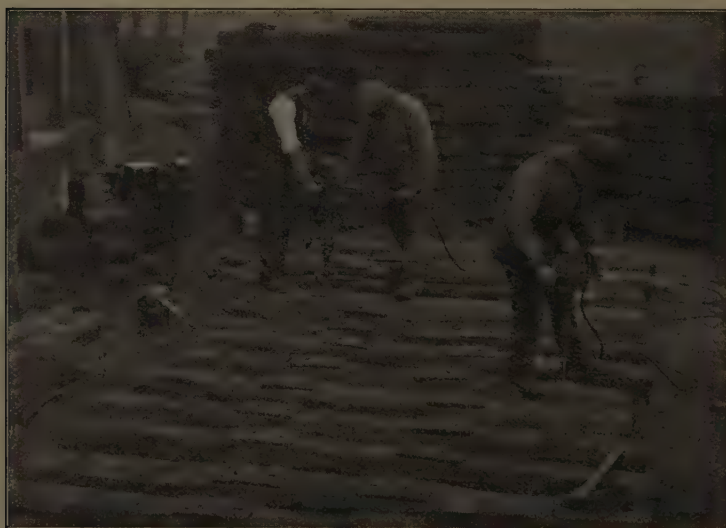


Fig. 18. — Sleeper boring machine in operation.



Fig. 19a. -- Hand tools connected to a generating set at work on the track.



Fig. 19b. -- The same tools at work at the depot.



Fig. 20a. — Mechanical fishbolt nut spanner. — Turning the nuts.



Fig. 20b. — Mechanical fishbolt nut spanner. — Tightening up the nuts.

an air pump, a supply of air which operates on the piston in the tamping tool through air pipes and moves the piston to and fro at a great speed.

The tamping tool is the real working tool in track maintenance. The piston is free to move to and fro in its cylinder. The actual tamping tool is inserted in a shaft which projects from the lower end of the cylinder. The packing tool can be changed according to the type of ballast, for instance for stone chips a small tool is used and for gravel a larger one. Two metal protected rubber pipes connect the cylinder of the tamping tool to the cylinder of the air pump. The grips are placed with their handles so fitted on the tamping tool that the direction of tamping with a machine is roughly the same as by hand tamping, and so that the workman is but little fatigued by guiding the tool.

All sleepers are only packed from one side, *i. e.* in double and multi-track lines, against the direction of travel. Only sleepers coupled together under rail joints or wide sleepers are tamped on both sides. The speed of the tamping tool is most effective when the crankshaft of the motor revolves at 1400 to 1550 revs. per minute. This speed must be kept as exact as possible and can be attained by fitting a governor.

This use of machine tamping tools is only economical when they can run continuously for the duration of the work without much interruption. The machines must not be used in loose ballast and also not in firm concrete-like hard ballast. For the first time tracks are tamped, when they still lie in loose ballast, the machines are less suitable. On the other hand, they perform good work for subsequent tamping and for the systematic maintenance of the track.



Fig. 21. — Track tamping machine.

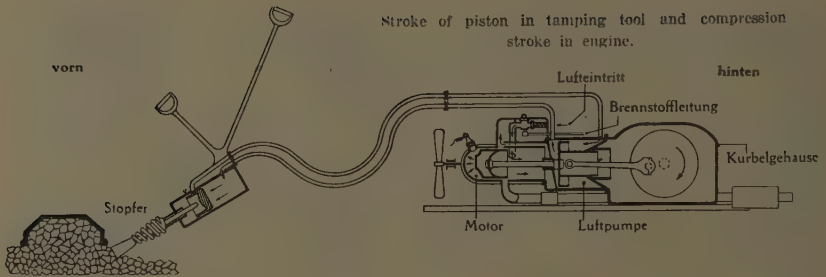


Fig. 22a.

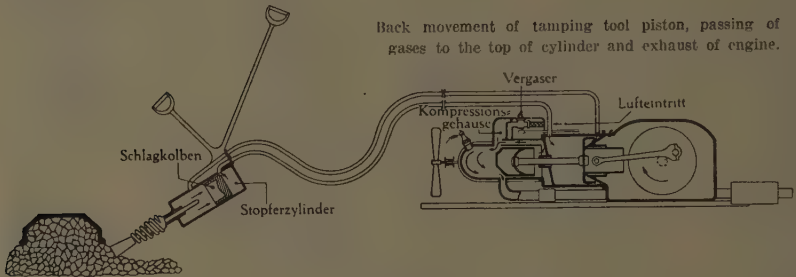


Fig. 22b.

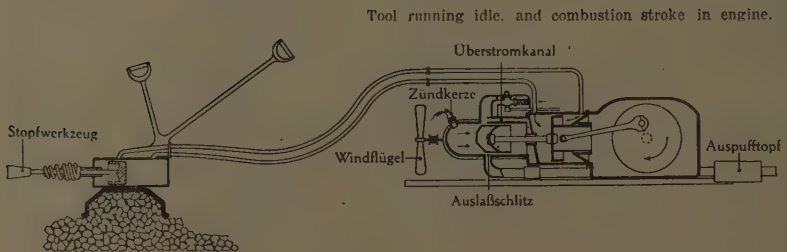


Fig. 22c.

Fig. 22. — Diagram of operations of tamping machine.

Explanation of German terms in Figs. 22 a, b, c: Auslass-Schlitz = Exhaust port. Auspufftopf = Silencer. Brennstoffleitung = Fuel pipe. — Hinten = Back. Kompressionsgehäuse = Compression chamber. — Kurbelgehäuse = Crankshaft housing. — Luft Eintritt = Air inlet. — Luftpumpe = Air pump. — Motor = Motor. — Schlagkolben = Piston. — Stopfer = Tamping tool. — Stopferzylinder = Cylinder. — Vergaser = Carburettor. — Vorn = Front. — Überstromkanal = Transfer port. — Windflügel = Air fan.

On account of the considerable noise made by these machines as well as other machines driven by power, special safety precautions are necessary. During bad visibility and foggy weather, working with tamping tools near running tracks is forbidden.

Figure 23 shows a tamping machine at work.

k) For removing weeds from the ballast and formation by chemicals, sodium chlorate in about 2 % solution has been recently used. For this purpose special spraying trains with tanks made out of old engine tenders are formed. The tenders are connected together and also to the tender carrying the spraying arrangement (see fig. 24). The tracks are systematically covered by this spraying train.

l) Rail saws are used for cutting rails on the site, these being usually electrically driven, the driving motor being the electric screwing machine with the box spanner taken off (see fig. 25). These rail saws can also be worked by hand.

m) For drilling the rails, rail drilling machines are used (see fig. 26). The holes can, however, also be drilled by using a screwing machine held in a simple cradle.

n) For inspecting the line, rail motor cars and motor line inspection trolleys are available for the inspection staff. Figure 27 shows a 6-seater rail motor car, of which each division of the Reichsbahn has one, and which is intended for the use of the divisional permanent way inspector and for the local district inspectors who accompany him; it is generally speaking designed like a road automobile. The car is equipped with an arrangement which in the simplest manner makes it possible in a short

time to turn, and in case of necessity to cross over to another line. Its maximum speed amounts to 50 km. (31 miles) per hour.

District officers and gang inspectors' sections with long maintenance districts are provided with motor line inspection trolleys, in order to make it possible for them more frequently to supervise the state of the track and the work in progress on tracks where there is little traffic. Figure 28 shows a motor line inspection trolley for district officers. There is room for two persons besides the driver, and in addition a trailer can be attached which will take another three persons.

Recently 2-seater motor line inspection trolleys have been allotted for the use of the chief inspector of gangs, of the type shown in figure 29, which are driven by an air-cooled internal combustion engine of 4 H. P. The two seats are arranged side by side: a leather apron is provided as a protection against the weather. The trolley is designed of such a weight that, having a capacity to give a maximum speed of 30 km. (18.6 miles) per hour, it can be removed from the rails, if necessity arises, by one man alone. The trolley is equipped with double brakes and affords room for carrying, amongst other things, tools or small hand appliances. For travelling at night it is equipped with a brilliant light and dimming device.

For continuous and exact observation and measurement of the track with regard to its condition from the point of view of safety, the Reichsbahn has recently put into operation, for its 78 000 km. (48 468 miles) of open main lines, a permanent way testing car fitted with recording instruments which makes it possible to carry out measurements under a moving load. Great importance



Fig. 23. — Krupp tamping machine at work.



Fig. 24. — Tank wagon train for destruction of weeds.

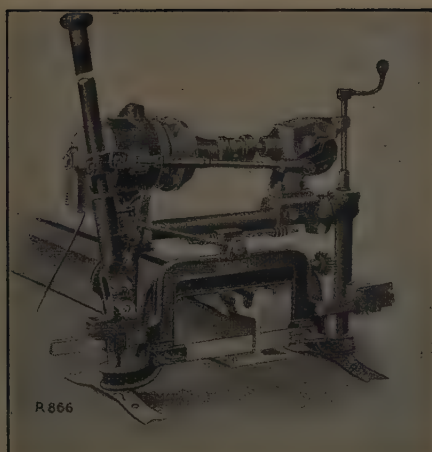


Fig. 25. — Electrically driven rail saw.

is attached to this, since the track under load shows a different picture from one without load. Figure 30 shows the interior of the testing car.

By means of the apparatus contained in the 60-ton car, the track is tested at a speed of 60 km. (37.3 miles) per hour for the following :

1. Deflection at the rail joints and of the rails.
2. Gauge.
3. Relative height of the rails.
4. Alignment of the track, particularly on curves.

In addition the speed and distance are registered. All registrations are taken on a recording band driven by the measuring axle. The band travels 151 mm. per km. (9 1/2 inches per mile).

Under (1) are measured the vertical movements of the centre axle of the 6-wheeled measuring bogie relative to

the line joining the two outer axles which is taken as the directrix. The vertical movements of the centre axle are transmitted mechanically on to the measuring table and drawn on the recording band by a recording pen.

The measurements taken for (2) are made by means of two sliding contact bows which slide along the running rail at a height of 14 mm. (9/16 inch) below top of rail level. The movements of the two sliding bows are transmitted by wires, etc., and so combined that the resulting movement registers the variation in the gauge in the proportion of 1 : 2.

For ascertaining the relative heights of the running rails (3) a gyroscopic wheel suspended as a pendulum with a vertical axis (see fig. 30b) is used. The wheel is driven by alternating current, and is so arranged that it is not influenced by the movements of the car

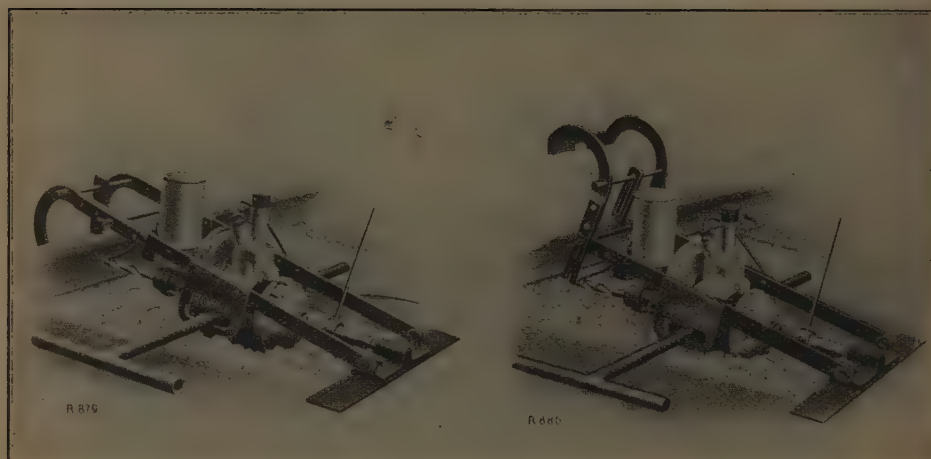


Fig. 26. -- Electric rail drilling machine.



Fig. 27 -- Six-seater rail motor car.



Fig. 28. — Motor-driven trolley with trailer for inspection staff.

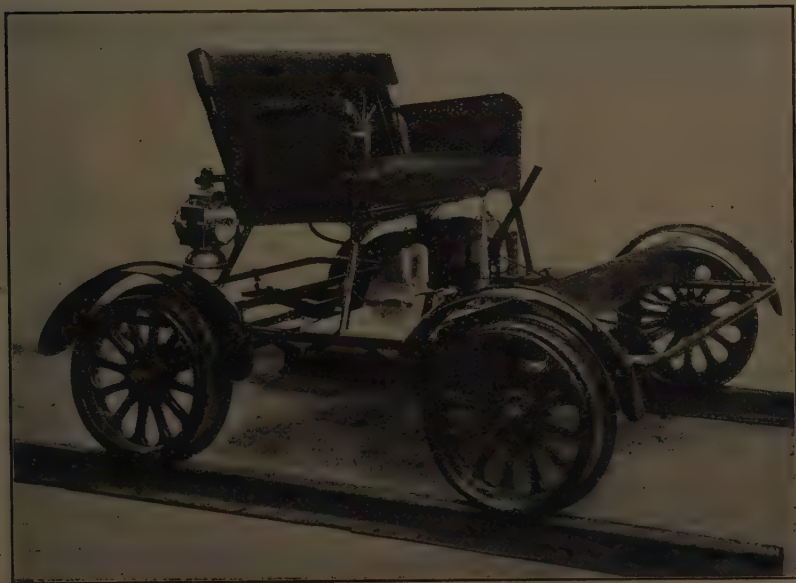


Fig. 29. — 2-seater motor-driven trolley for the permanent way inspector.



Fig. 30a. — Interior view of the permanent way testing car.

itself. Each variation in the angle between the measuring axle and the axis of the revolving wheel is registered on the recording band by electricity in the proportion of 1 : 5.

For ascertaining the alignment of the track (4), each movement of the car round its vertical axis is measured and registered by a double gyroscopic compass (see fig. 30c). Each curve which has a constant radius is shown by an inclined line which is, however, in itself straight. The specimens of the recording bands shown in Appendices 5-6 show generally the picture obtained by the car of a good and bad track. The most important lines are covered by this car if

at all possible twice a year, and the less important, once.

#### 4. — Cost of the appliances.

The costs of the most important are approximately as follows :

	Reichsmarks.
1 ballast roller . . . . .	11 000
1 self-discharging ballast wagon with brakes . . . . .	7 000
1 self-discharging ballast wagon without brakes. . . . .	5 400
1 rail loading device for each crane . . . . .	325
1 ballast box for sleepers other than joint sleepers. . . . .	31



Fig. 30b. — Permanent way testing car.  
Gyroscope for ascertaining the respective heights of the running rails.

1 ballast box for broad sleepers . . . . .	50	1 track layer :	
1 trolley with motor according to type . . . . .	8 000-8 500	Mohr & Federhaff type . . . . .	38 000
1 single rail trolley . . . . .	90	Hoch type . . . . .	33 000
1 portable electric generating set with three driving motors and lighting standards according to capacity . . . . .	5 000-6 600	Niemag type . . . . .	33 000
1 track winch with a capacity of 5 tons . . . . .	70	Track laying apparatus of the Neddermeyer Co. has not yet been purchased.	
1 track winch with a capacity of 10 tons . . . . .	80	1 set of rollers, 6 units, for a simple set of switches . . . . .	420
1 tamping machine . . . . .	3 300	1 set of rollers, 8 units, for switches and crossings . . . . .	560
		1 rail motor car . . . . .	15 000
		1 motor line inspection trolley . . . . .	2 400

The above are average prices which, according to the requirements as to equipment and capacity, can be more or less.

### 5. — The economics of the appliances.

The economies obtainable from work done by machinery are very largely dependent on the machines being employed to their full capacity. As the machines can only be used during favourable seasons, which means in Ger-

many on the average at the most nine months, the maximum employment of the machines, after deduction of the time taken up by holidays and maintenance, is obtained with about 200 working days per annum.

The economic advantages which may generally result can be seen from the following comparisons of certain work, i. e. time and men required with machine and manual labour, other conditions remaining the same.

	With machinery	Manual labour exclusively.
Ballast consolidated per day. . . . .	300 m.	75 m. of track.
Discharging 12 1 2 m <sup>3</sup> 16.3 cubic yards of ballast . . . . .	10	300 minutes.
Loading 15-m. (49 ft.-2 1/2 in.) rail by means of rail loading device . . . . .	6	22 men.
Laying steel sleepers and materials for 1 km. (0.62 mile) of track using ballast boxes . . . . .	400	600 man-days.
Laying a two-way switch using rollers . . . . .	15	60 men.

The advantages which are gained from the power driven machines most in use are given as follows :

#### a) Portable generating sets.

The costs for a given job using portable electric generating sets, based on recent figures are made up as follows :

Fuel . . . . .	6.9 %
Lubricating oil . . . . .	1.6 %
Wages . . . . .	62.1 %
Wages for upkeep . . . . .	4.0 %
Replacement . . . . .	6.0 %
Interest and amortisation . . . . .	19.4 %
	<hr/> 100.0 %

These figures will naturally vary according to the purpose for which the generating sets are chiefly used. They are at present used in connection with maintenance work, for boring wooden

sleepers, for screwing and unscrewing coachscrews, for screwing up and loosening nuts, for dowelling wooden sleepers, for boring longitudinal timbers for bridges, for cleaning up the threads of bolts, for rail sawing, for rail drilling and for illuminating the site.

Without the generating set, and excluding the lighting, 157 % of the actual cost would have to be expended to do the same work. The saving as against manual work amounts in all including all costs to 36 %.

The portable electric generating set in conjunction with one electric tool works after its 33rd working day, no more expensively than if the work had been done exclusively by hand. In this way the costs become reduced when the set is fully employed during the year to about half the costs of manual work. If three electric hand tools are continually used



Fig. 30c. — Permanent way testing car.  
Double gyroscopic compass for indicating the alignment of the track.

in conjunction with the generating set, the equalisation of the costs between machine and manual work is already obtained after the ninth working day. With the full employment of the set during the whole year, the costs are reduced to about one quarter of those for manual work.

**b) Machine tamping tools.**

The costs for operating machine tamping tools are made up fairly constantly as follows :

Wages . . . . .	60.5 %
Fuel . . . . .	14.6 %

Lubricating oil . . . . .	2.4 %
Wages on upkeep . . . . .	2.6 %
Replacements . . . . .	8.2 %
Interest and amortisation . . . . .	11.7 %
	<hr/> 100.0 %

Other things being equal, tamping by hand costs 132 % for the same work, and the saving as against manual work amounts to 24 %.

Machine tamping tools pay for themselves after 30 man-days. The costs of machine and hand work are then the same. If the costs of tamping of one

metre of track are taken at 1.35 Rm. which corresponds to an average capacity of about 5.50 m. (18 feet) tamping work per man and per day, machine work will cost, based on 30 man-days the same; based on 107 man-days, as was attained in 1928, 1.11 Rm. and based on approximately 180 man-days, that is to say with the fullest possible employment of the machine and with an average day's capacity, 0.99 Rm. In this manner the saving can be increased up to 30 %. The average daily capacity of a machine tamping tool is about 55 m. (180 1/2 feet).

#### c) *Track laying apparatus :*

##### 1. — *Mohr and Federhaff type.*

The costs for track laying work using this appliance taking into consideration the amounts written off up to date, may be shown as follows :

Wages and other fees . . . . .	64.0 %
Fuel . . . . .	1.4 %
Lubricating oil . . . . .	0.2 %
Upkeep of crane . . . . .	3.8 %
Use of locomotives . . . . .	19.4 %
Interest and amortisation . . . . .	11.2 %
	<hr/>
	100.0 %

The costs when using the crane amount to 0.60 Rm. for 1 metre of track for taking up and dismantling the section of track and for the assembly and laying 0.95 Rm.; here it must be pointed out that all other work is done by the contractor and is therefore not included. With manual labour exclusively the costs would amount to 1.20 and 1.30 Rm. respectively, so that the saving amounts on the average to 38 %.

An important factor in the economy obtainable with this crane is that it can

not only be used for track laying, but also for transportation of materials in the stores and on the line. It can therefore be used to better advantage than the cranes described later.

##### 2. — *Hoch type.*

When this type is used the costs of track laying are approximately as follows :

Wages and other fees . . . . .	73.0 %
Fuel . . . . .	1.4 %
Lubricating oil . . . . .	0.3 %
Upkeep of crane . . . . .	1.7 %
Use of locomotives . . . . .	12.0 %
Interest and amortisation . . . . .	7.8 %
Special permanent way machines used . . . . .	3.8 %
	<hr/>
	100.0 %

The costs when using this crane have amounted to 0.80 Rm. for taking up and 3.00 Rm. for laying the track including all work. With manual labour exclusively these would have amounted to 1.10 and 3.40 Rm. respectively. The total saving amounts therefore to 16 %.

This result is of course capable of being improved with stricter organisation, and when the men have become familiar with their work, and also especially when fairly long intervals are available between trains.

##### 3. — *Niemag type.*

The costs for track laying are made up as follows :

Wages and other fees . . . . .	79.0 %
Fuel . . . . .	1.5 %
Lubricating oil . . . . .	0.3 %
Upkeep of crane . . . . .	1.8 %

Use of locomotives . . . . .	9.0 %
Interest and amortisation . . .	7.5 %
Special permanent way machines	0.9 %
	<hr/>
	100.0 %

The costs of taking up and laying track amount to 3.25 Rm. per metre of track when using this appliance. As against exclusive manual labour which costs 4.50 Rm. per metre, a saving of about 28 % has been attained. This result has been obtained by means of good organisation, by the workmen having become familiar with the job, as a result of long intervals for work up to 8 hours, and because of the favourable positions of stores. From a comparison of the various items it can be at once seen how much the economies obtainable are influenced by these factors.

#### 4. — Neddermeyer type.

Carrying out track laying work with this appliance which was loaned to us, has given the following costs :

Wages . . . . .	94.0 %
Fuel . . . . .	0.8 %
Lubricating oil . . . . .	0.1 %
Upkeep of apparatus . . . . .	0.1 %
Use of locomotives . . . . .	2.9 %
Interest and amortisation . . .	2.0 %
Special permanent way machines	
used . . . . .	0.1 %
	<hr/>
	100.0 %

Costs for the complete renewal of track using this machine amounted to 3.35 Rm., whereas using manual labour exclusively it would have cost 4.50 Rm. The saving therefore amounts to about 26 %. The economic results given by the machine are naturally considerably influen-

ced by local and operating conditions. If the machine is used on sharp curves or on lines having dense traffic where only small intervals are available between trains, its economic advantage is considerably decreased. A further important factor is the condition of the track to be renewed which according to its state requires a greater or smaller amount of attention. It is therefore difficult to lay down a definite rule for the number of hands required. On the contrary it must be ascertained from experience of various cases what number is required so that not only the appliance but also the other working factors can be used to best advantage, and so that a good economic result can be obtained. That is a question of organisation and arrangement, the complete solution of which depends considerably on the executive.

It is useful to make up a programme of work for using a track laying appliance :

- a) Fixing the places where work is to be carried out;
- b) Arranging the staff;
- c) Connecting up the track work with ballasting and sundry work;
- d) Fixing the order of the work;
- e) Fixing the intervals between trains in conjunction with the operating department whereby care has to be given to taking full advantage of the intervals and to the speedy arrival of the service train at the site;
- f) Punctual arrangements for the necessary materials.

A programme of work made up on such lines renders possible a systematic and economic carrying out of the work; for the superiority of machine work over manual work depends, as should at this

point again be mentioned, to a large extent on the exact division of the work and the strictly limited expenditure of labour. An engineer is necessary for the purpose of ensuring its correct operation and condition, and it is his duty to take care that the machine is always in proper running order. For the portable generating sets also, an engineer is necessary who can, however, be used on other work. The driver of the ballast rollers and the motor attendant of the track laying appliances have to keep their generating sets in order during operations. More important renewals and repairs on all machines are carried out in the repair shops and all machines are overhauled in the latter during the winter.

The use of mechanical auxiliaries of any kind is only advantageous and economical when long stretches of track have to be renewed and maintained, that is to say, when the site is seldom changed. We have already taken this into account in that we renew as long connected length of track as possible and in addition carry out the work systematically.

The average daily capacity of a tamping machine amounts to about 55 m. (180 1/2 feet), or in the case of a set — 4 machines — 220 m. (722 feet). The smallest length of track for which it pays to use a set of machines would be about a week's capacity i. e. about 1 300 m. = 4 264 feet.

The track layers can take up and relay up to 180 m. (590 feet) of track per hour. These machines cannot be economically employed during periods of less than 3 hours, because it takes too much time to bring the service trains up to the site and back. They can only therefore be

used with economic success in cases where there are 3 km. (1.86 miles) of track to relay and where a continuous period of 3 hours per day at least is available. This is also the case with ballast rollers. For all the other machines it is difficult to specify a length of track, since their economic employment depends rather on the extent of the work to be done. Even if the machines to be introduced have to bring in the first place economic advantage, nevertheless in certain circumstances they have to be used where other factors must be taken into consideration, as for instance:

For speeding up the work in short intervals on tracks having dense traffic, in order to reduce as far as possible unavoidable delays to traffic, and in those cases where machine work is better than manual work, that is to say, where it offers technical advantages.

In this respect machine tamping is superior to tamping by hand, as it is done more regularly and with always the same power, so that a regular firm sleeper foundation is obtained, whereas with hand tamping, according to the force used and the extent of fatigue of each individual workman, the sleepers are firmly or less firmly tamped, which very soon makes itself noticed by giving an uneven track.

The advantages of rail motor cars and motor line inspection trolleys lie in another direction. They render possible a frequent inspection by the proper officials of the operations on the track, and therefore indirectly help the work.

## 6. — Power sources for the appliances.

The majority of power driven machine auxiliaries have their own source of

power, *i. e.* an internal combustion engine as already described in detail. Sometimes a dynamo is coupled to this motor for generating electric current which can also be used for lighting purposes. As a source of power for the electric hand tools the portable electric generating set already described is used. At stations and working sites, electric current is taken from the mains.

In the cases of those machines having their own source of power, it is obvious that the period during which the power is available is limited to the time during which this machine is being used.

The portable electric generating sets can on the other hand be also used while the track on which work is being done is open to traffic, and can be used for all work which can be carried out with electric hand tools outside the track in use for the assembly and dismantling of the track, and also for the electric lighting of the site.

The portable generating set is, as indicated by its name, portable. It can either run on its own wheels or be moved in a small truck, and can also be placed on the side of the track in use outside the loading gauge so that the line is kept open. The rubber cables which connect the generating set with the electric hand tools are of such a length that 150 m. (492 feet) can be dealt with without the generators being moved. The lighting equipment which can be attached to the generating set consists of several lights fitted to eight standards, 25 m. (82 feet) apart so that a site of over 200 m. (656 feet) in length can be fully illuminated with 500-watt lamps and with a candlepower of about 1 000 each.

## **B. — Economic organisation of track maintenance.**

### **1. — Organisation of track maintenance in Reichsbahn Divisions and in the districts allotted to them.**

In Section A it has already been pointed out that machine auxiliaries for the renewal and maintenance of the permanent way can be used if it is done in a proper and systematic manner. This naturally makes it essential that the permanent way work itself is properly organised and systematically carried out. For this, however, individual management of all matters concerning permanent way is necessary in each executive district of the railway divisions; for only an individual mind ensures purposeful and objective work.

For this reason, there was appointed already in 1920, for each railway division in Prussia-Hessen, a divisional permanent way superintendent, and by this means it was ensured that all permanent way matters of a technical as well as personal nature were dealt with in a proper manner in accordance with the regulations issued by the Central Office, now the General Headquarters of the Reichsbahn. In the meantime this practice has also been extended to the other divisions so that now individual management of all matters dealing with permanent way in each division is ensured all over the Reichsbahn.

Divisional permanent way inspectors are allotted to the divisional permanent way superintendents who chiefly have to see that the permanent way work on the line is practically carried out, and for this act in an advisory capacity.

Whereas individual management of all

matters connected with permanent way was fully attained from the purely technical point of view by the appointment of divisional permanent way superintendents, nevertheless an individual handling of matters connected with permanent way materials, the management of working shifts, and the other duties connected with outside work which have to be carried out by the divisions, was often missing. This deficiency has been recently attended to and the individual business management of all permanent way matters has been handed over to a special permanent way office under the immediate control of the divisional permanent way superintendent.

With reference to the extent and importance of the lines, the territory of the railway divisions varies in accordance with the importance of the track they control. On the average each division has to look after 4 300 km. (2 670 miles) of track, of which 2 700 km. (1 680 miles) are main lines and also about 10 000 switches reckoned on a single switch basis.

The duties of carrying out and the supervision of track maintenance falls to the district officers which have to deal with constructional as well as operating matters.

The number of district officers is 328. They have to attend to on the average 370 km. (230 miles) of track including 240 km. (150 miles) of main lines and 900 switches reckoned on a single switch basis.

For local supervision, maintenance and extensions, there are 2 920 gangs of which only 2 720 concern the permanent way. Of the remaining gangs 80 have to deal with buildings only, 95 with signalling installations, 2 with bridges,

and the rest with other installations. Each track inspection district consists of on the average 45 km. (28 miles) of track to maintain including 29 km. (18 miles) of main line and 110 switches.

It is intended to standardise the area given to the gangs so that each inspector can easily look after his own district but is kept fully employed under normal conditions with ordinary maintenance work.

For special work, which occurs intermittently, such as considerable renewals of track and ballast, extensions, etc., the chief of the gang must get temporary assistance by obtaining help. By this the number of gangs will be probably reduced.

For carrying out the work, the gangs have to cover about 7 200 sections, *i. e.*, on the average 2.6 for each main gang.

The extent of the territory covered by the district officers and gangs under the charge of an inspector, varies just as it does in the case of the railway divisions. It depends on the amount of work to be done, which is usually determined by the density of the traffic as well as by purely local conditions. As a result, the maintenance staff is not divided regularly but in accordance with the necessity imposed by operating and local conditions.

When fixing the location of the district offices, etc., consideration is given that these should be as nearly as possible in the centre of their district, that is to say, at the place where most work has to be done, but importance is also attached to arranging their position in as favourable a spot as possible in their working territory, so that all points can be reached in a short time.

The inspection and maintenance of

signalling and telegraph installations, tunnels, bridges, etc., usually falls to the district officers and gangs. Separate offices are not usually provided for this purpose. Only in the case of large stations with extensive signalling and telegraph apparatus is their inspection and maintenance given over to special inspectors, so-called signalling inspectors. In some divisions formed out of the earlier organisations of the previously separate State Railways, the old arrangement still remains, which had separate supervision and maintenance offices for signalling and telegraph work. It is, however, intended that these shall conform to the general rule. For buildings, special building inspection offices are only provided at large stations with numerous and extensive buildings. In addition, in two places there exist bridge inspection departments for portable pontoon bridges which as soon as permanent bridges are built, will be abolished.

The gangs are provided with signal mechanics for the maintenance of the signalling apparatus, line inspectors and telegraph mechanics for the maintenance of telegraph apparatus, and ordinary mechanics who act as handy men for carrying out minor maintenance work. The gangs on larger stations employ also according to requirements, a few workmen such as bricklayers, carpenters, painters, plumbers, etc.; generally speaking, however, the employment of ordinary mechanics and the railway's own labourers is limited to such instances in which outside labour cannot be used on account of the danger or where it is uneconomic on account of loss of time; otherwise outside workmen are employed. For testing bridges as well as for other minor maintenance

work, bridge fitters are used who are either withdrawn from repair work or if they can be continually employed, are allotted to a gang. For the new installation of telegraph equipment, mechanics are collected from several districts.

For all other railway maintenance work, unskilled workmen are employed.

Track supported on temporary structures, and track in tunnels and on bridges is only specially watched where unusual conditions make this temporarily necessary, as for instance, in the case of snow drifts, floods, pack ice, heavy frost, danger of fire, etc., otherwise the usual inspection is considered sufficient. Movable bridges are excepted, these being permanently provided with an attendant, on account of the attention required, and he is under the control of the gang.

Even the special inspection of this track is limited to the above mentioned exception. Tunnels, however, are closely examined at least once a year by the head of the district office, by means of a tunnel testing car. Bridges are given an ordinary inspection at intervals of two years, and a close inspection at intervals of six years. In the case of simple inspections, the head of the district office can depute his assistant or another suitable official, or in the case of particularly simple jobs, even the chief inspector of the gang. All close inspections are carried out by officials from the divisional bridge and constructional steel building departments. The chief inspector of the gang in question has to be present at all close tests. In the case of particularly weak or dangerous bridges, the interval of time between

tests can be reduced according to requirements, and in the case of simple lane and road bridges the intervals can be increased.

The track must, on main lines, be examined as to its condition at least once every day and on secondary lines every other day. For this platelayers are usually employed, whose chief duty is the examination of the line, but who must also carry out in addition minor maintenance work such as tightening loose coachscrews, etc. These platelayers have to examine the permanent way for irregularities in the gauge, and in the height and position of the track, which result from the twisting and sinking of the track, frost, etc., or are occasioned by other causes dangerous to operation, and to examine the permanent way materials for cracks, breakages, etc. The small faults, they have to attend to themselves, and the important ones have to be reported to the inspector.

On tracks on which level crossing and track supervision are not under separate control, the gatekeeper or the attendants assist within a certain area in the duties which fall to the platelayer. In mining districts where subsidences are feared, increased supervision and examination of the endangered track is carried out according to circumstances.

## 2. — Recent developments in track maintenance for increasing economy.

Reference has already been made at the beginning of this section to developments which have been introduced in recent years and which it is intended to introduce in order to render more economical the maintenance of track. There still remains, however, a development

which has proved itself valuable particularly in industrial districts where experience has shown that it is difficult to meet labour requirements, and this is the flying gang.

These flying gang is housed in a special train (see fig. 31) and moves from site to site. Its strength is such that it can deal with its chief work such as track, switches and crossings and ballast renewals quickly and properly. As a rule its strength is 60 to 80 men, and an able energetic man is put in charge, and according to the strength of the gang, three or four foremen and a clerk are allotted to him for this difficult and responsible special service. The gang is chiefly formed from temporary workmen who in districts where sufficient labour is available, are put on for the period of operation, *i. e.* March to the end of October, and from a few permanent hands who in particular attend to and look after the machinery.

The economic advantage to be gained by the use of gangs rests principally in the fact that a large body of men remain continually together with relatively small changes in the personnel, whose individual workmen carry out almost always the same duties and who therefore are familiar with the work and who work well together. The gang is controlled by the district officer as far as personnel is concerned and by the division on the technical side. The division acquaints the gang with the site and programme of work under advice to the district officer concerned. The gang otherwise acts as an independent service unit and acts so to speak as contractor to the inspector in whose area it works, he having to supervise and pass its work.



Fig. 31. — Living-in train for a « flying gang ».

The service train consists of living carriages, one kitchen wagon, and one tool wagon. Each living carriage contains six to eight camp beds. Special rooms are fitted up for the man in charge, the foremen and the clerk, which contain writing desks and a telephone.

### 3. — Details of the Reichsbahn standard track.

The Reichsbahn as a result of the experience collected under the most varying conditions from the former separate State Railways, and, as a result of their own tests carried out on the construction of its permanent way over a period of many years, has laid down certain principles, the most important of which are given in short below :

Rails and sleepers must be as far as is possible immovably connected by their fastenings.

Soleplates with hooks rolled or cast on have proved themselves unsuitable for the fastening of rails. Arrangements by which the rails are firmly screwed down on to their supporting plates on both sides are preferable.

Loose steel soleplates have not proved themselves in permanent way with steel sleepers since it is not possible in this manner to obtain a lasting and tight connection of the parts.

As a rule, not more than two parts should be joined together by one screw and for this reason in the case of permanent way on wooden sleepers the rail fastenings must in all circumstances be separate from the soleplate fastening.

The nuts and bolts used for fastening the running rails must be capable of being inserted from above, and of being replaced at any time without having to disconnect the fastening between the soleplate and the sleeper.

The canting of the running rails towards the centre of the track at an inclination of 1 : 20 which has been usual from the beginning of railways is also to be retained in the future, in order to minimise the pressure on the soleplates occasioned by the side movement of the wheels and in order to avoid side stresses. Apart from this, if the position of the rails were vertical, on account of the existing coning of the tyres which cannot

in practice be altered, used rails could not be employed because of the unsuitable bearing surface which would then be obtained.

For the standard Reichsbahn track, these principles have been observed as can be seen from figures 32a to 32g. In addition the closest attention has been paid to operating requirements, namely to the transporting of heavier loads and increasing speeds.

The whole network of the Reichsbahn lines, independently of the division of the tracks into main line and secondary lines, from the operating point of view, is divided purely from a permanent way point of view into tracks of first, second and third classes.

The first class tracks are those with dense traffic, high train speeds and the greatest axle loads. In this group the most important tracks which deal with the international and long distance express traffic (Fern-D-Züge) are taken as a special class.

The second class tracks are those with average traffic and generally speaking lower train speeds, but without regard to the axle loads.

The third class tracks are those remaining.

Only first class tracks including the special tracks are renewed with new materials, this being done systematically according to their traffic requirements at greater or less intervals, on the average every 18 years. These tracks are equipped with the Reichsbahn track K on wooden or steel sleepers.

The materials taken out when renewing first class track which can again be used to a large extent after the addition of certain new materials, viz. sleepers and fastenings, are used for the renewal

and maintenance of second class tracks. These are the less important main lines at principal stations, the main track on secondary railways, shunting loops, and crossings, goods train reception sidings and departure sidings as well as important shunting tracks. Their renewal is also carried out systematically at greater or less intervals, on the average every 20 years.

The materials regained when renewing second class track which can still be used are employed for renewing and maintaining third class track, that is, the least important lines.

There are, in all, three groups of track through which the materials pass until they are completely worn out in order then to be used again as scrap, building timber or firewood. The lengths of track belonging to each group stand in such a proportion to each other that the materials gained which are still serviceable are sufficient in each instance for the maintenance and renewal of the tracks which come into question, and the time the materials lie in the track in the three groups is equal to the life of the materials themselves. This naturally only applies generally speaking to the principal materials, since sleepers and, above all, fastenings must to a certain extent often be replaced during the life of the track.

This method offers the advantages that the most important<sup>6</sup> lines have a permanent way sufficient for all requirements, whereas the old permanent way is amply sufficient for the tracks for which it is used. For this reason lighter permanent way types are not specially obtained for these tracks.

In designing the new Reichsbahn track K the principle was observed that a permanent way for wood and steel sleepers

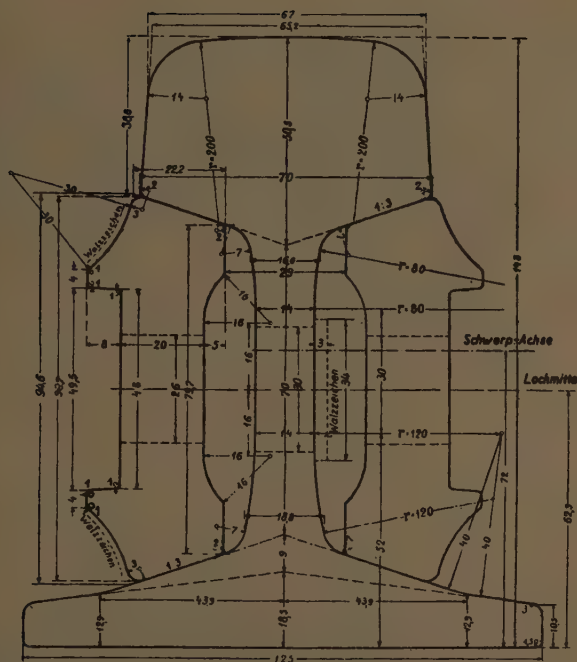


Fig. 32a. — Cross section of rail and fishplate.

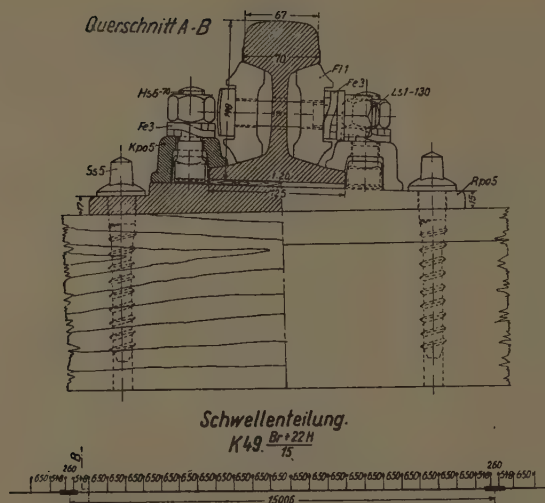
should be made which, however, provides the same means of fastening for both types of sleeper, a fact which allows political economic considerations to be taken into account, and which offers considerable economic advantages for their supply as well as maintenance.

The permanent way on wooden and steel sleepers is designed for a wheel load of 12.5 tons.

The rail in 148 mm. (5 13/16 in.) high, the foot 125 mm. (5 inches) wide, the web in the middle 14 mm. (9/16 in.) thick. It weighs about 49 kgr. per m. (98.8 lb. per yard). In the special class track, rails of 30 m. (98 ft. 5 in.) are used, and in

the remaining first class tracks 15 m. (49 ft. 2 1/2 in.). Only on viaducts and on long bridges of stone, concrete and reinforced concrete are rails of 30 m. (98 ft. 5 in.) length used, in order to reduce shocks as far as possible.

A rail length of 30 m. is not generally exceeded owing to the difficulties which arise in the track due to the variations in the length of the rail caused by the alterations in temperature, and on account of the difficulty of handling the rail on the track. Only in tunnels and on steel bridges are the rails welded together to a greater length, namely up to 120 m. (394 feet). Overlapping devices



## Spurregelung.

Halbmesser bis einschl. m	Spurerweiterung mm	Bemerkung
300	0	Die Schwellen werden je nach Bedarf für 5 mm, 10 mm oder 15 mm Spurerweiterung gebohrt
230	5	
160	10	
unter 160	15	

Fig. 32b. — German permanent way, type K with rails type S. 49 on wooden sleepers.

[Experiment]

(Permissible wheel load = 12.5 tons.)

Explanation of German terms in figs. 32 a, b: Bemerkung = Remarks. — Die Schwellen werden je nach Bedarf... = The sleepers are bored for 5 mm., 10 mm. or 15 mm. adjustment in gauge as required. — Halbmesser bis einschl. = Radius up to... inclusive. — Loch mitte = Centre of hole. — Spurregelung = Adjustment of gauge. — Spurerweiterung = Increase of gauge. — Schwellenteilung = Spacing of sleepers. — Schwerp.-Achse = Centre of gravity. — Walzzeichen = Rolling mark.

are fitted on steel bridges for compensating the variations in temperature, but in tunnels these are not used owing to the variations being small.

For making up the difference in rail length in curves, making-up rails are

used, which for 15-m. (49 ft. 2 1/2 in.) rails are 14.96 (49 ft. 1 in.), 14.92 (48 ft. 11 7/16 in.) and 14.88 m. (48 ft. 9 13/16 in.) long and for 30 m. (98 ft. 5 in.) rails are 30.060 m. (98 ft. 7 1/2 in.), 30.110 m. (98 ft. 9 1/2 in.) and 30.165 m. (98 ft. 11 5/8 in.)

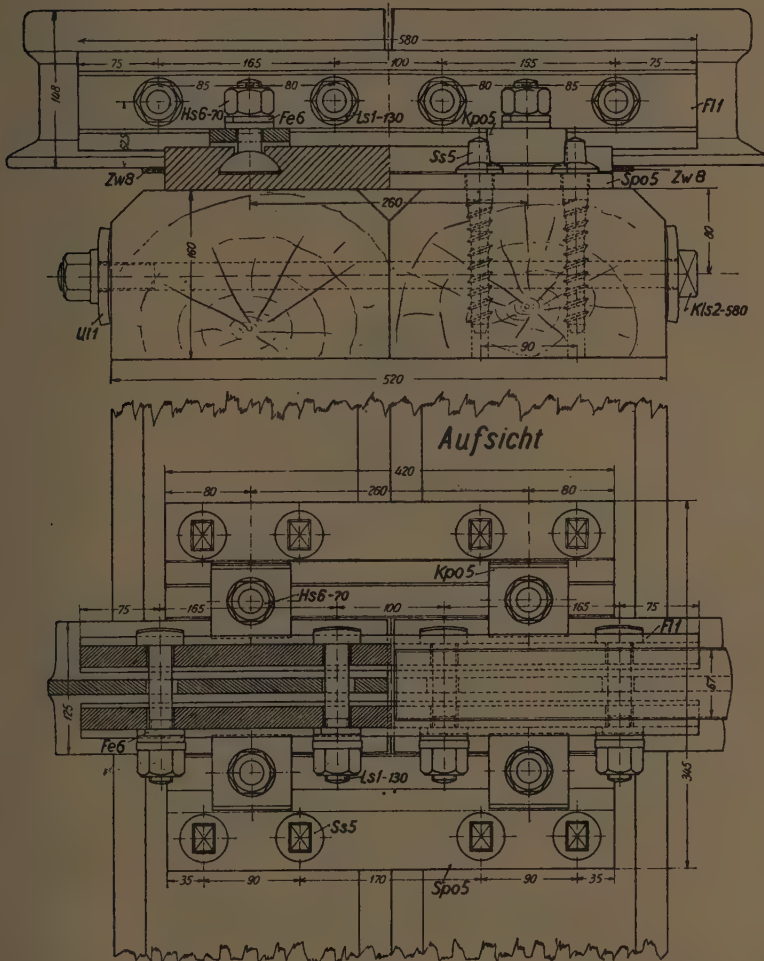


Fig. 32c. — Rail joint with wooden sleepers. — Plan.

long. In curves the make-up rails for 15 m. rails are laid inside the track, and for 30 m. rails outside the track. The latter arrangement has been chosen

because the make-up rails when they are taken up at a later date can be shortened to the standard length of 30 m.

At the rail joints with wooden sleepers,

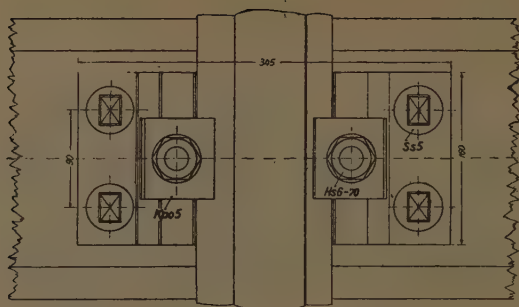


Fig. 32d. — Plan of rail on intermediate sleeper (wood).

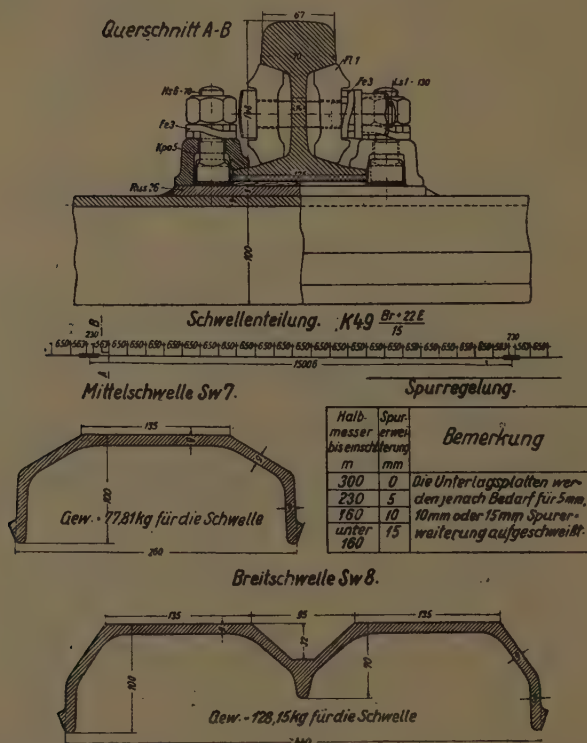
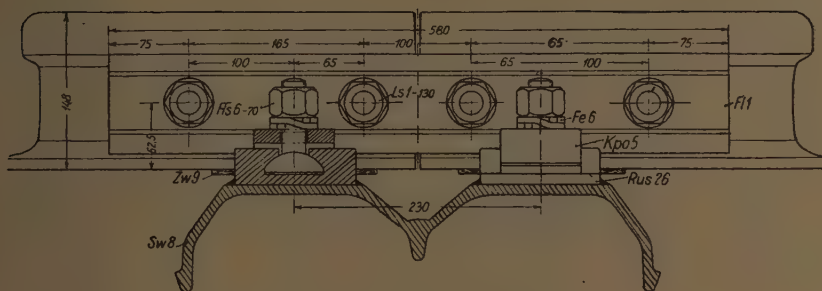


Fig. 32e. — German permanent way, type K with rails type S. 49 on steel sleepers.

[Experiment]

(Permissible wheel load = 12.5 tons).

Explanation of German terms: Bemerkung = Remark. — Breitschwelle = Wide sleeper. — Die Unterlagsplatten, etc... = The sole plates are welded on so as to give 5 mm., 10 mm. or 15 mm. increase of gauge as required. — Gew. 77.81 kg. für die Schwelle = Weight per sleeper: 166.85 lb. — Gew. 128.15 kg. für die Schwelle = Weight per sleeper: 283.05 lb. — Halbmesser bis einsch. m. = Radius up to... metres. — Mittelschwelle = Ordinary sleeper. — Querschnitt A-B = Section A-B. — Spurerweiterung = Increase of gauge. — Spurregelung = Adjustment of gauge. — Schwellenteilung = Spacing of sleepers.



*Aufsicht*

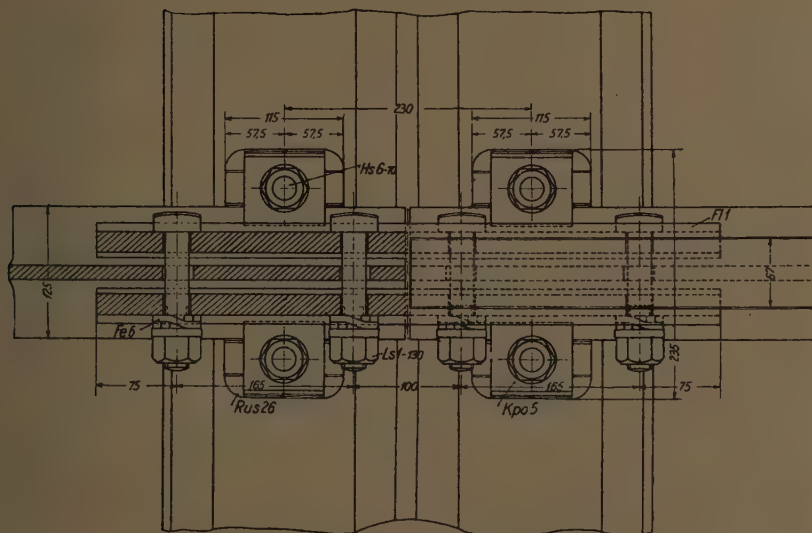


Fig. 32f. — Rail joint with steel sleepers. — Plan.

a double sleeper is used and with steel sleepers, a broad sleeper. A firm joint can therefore be obtained, but, by means of a groove in the soleplate under the joint in the case of wooden sleeper track, and by means of the recess between the

two halves of the broad sleeper in the case of steel sleeper track, the rails are allowed a small amount of play.

For connecting the rails heavy symmetrically formed flat fishplates without angles are used with a double ridge on

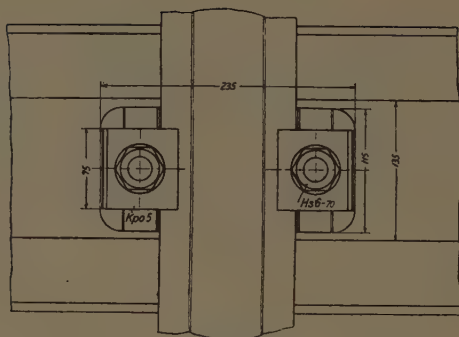


Fig. 32*g*. — Plan of rail on intermediate sleeper (steel).

the outside to hold the head of the fishbolt. They are held together by four fishbolts, and support the ends of the rails well. At present the flat fishplate is 580 mm. (22 13/16 inches) long, the two inner holes are 100 mm. (3 15/16 inches) and the two outer holes 165 mm. (6 1/2 inches) apart. The weight of a flat fishplate is 9.06 kgr. (20 lb.).

The German track type K is laid on wooden and steel sleepers. Technical, local and economic reasons govern the choice of the type of sleeper. Steel sleepers, for instance, cannot be used where atmospheric or local influences would soon destroy them. Wooden sleepers are produced mostly in the East, and steel sleepers in the West. The districts on which each kind is used will depend on the price and the cost of transport. On the special class tracks only wooden sleepers are used on principle.

First class tracks including the special class, are equipped with type I wooden sleepers 2.60 m. (8 ft. 6 3/8 in.) long and 16×26-cm. (6 5/16×10 1/4 inches) section, while for the remaining tracks, as well as for maintenance purposes type II wooden sleepers, 2.50 m. (8 ft. 2 7/16 in.)

long and 14×24-cm. (5 1/2×9 7/16 inches) section are used. The sleepers are usually machined on four sides, but sometimes only on two; the majority are made of pine, but to a small extent of larch. For tracks with denser traffic, on sharp curves and gradients, hard wood beech sleepers are used. Oak is used for crossing timbers, and for ordinary sleepers only as they occur during the manufacture of crossing timbers.

For their better preservation, the sleepers are impregnated with tar according to the Rüping process, and at the impregnation works are first planed and bored, so that the wood round the bored holes is well impregnated and the life of the sleepers thereby prolonged. After impregnation, the bearing plates are screwed on by a machine at the impregnation works.

For Reichsbahn track on steel sleepers, the type shown in figure 32*e* is used. They are 2.50 m. (8 ft. 2 7/16 in.) long and 260 mm. (10 1/4 inches) broad on the bottom side and 100 mm. (3 15/16 inches) high as with wooden sleepers. The upper surface is 135 mm. (5 5/16 in.) wide. The walls of the sleepers are 9 mm.

(3/8 inch) thick, the weight amounts to 28.85 kgr. per metre (58.2 lb. per yard) for an ordinary sleeper and 47.64 kgr. per metre (96 lb. per yard) for a broad sleeper. On these sleepers rib-plates, which in conformity with the principles set out above are designed similar to those for wooden sleepers, are electrically welded on. The ordinary sleeper complete with rib-plate weighs 83.58 kgr. (183.2 lb.) and the broad sleeper 139.69 kgr. (307 lb.).

Through the steel rib-plates being welded on, not only are the holes previously necessary for accommodating fastenings in the steel sleeper with all their harmful effects on its life avoided, but the sleepers are in addition considerably strengthened under the rail seat where they are submitted to most stress.

For a rail length of 15 m. (49 ft. 2 1/2 in.) one double or broad sleeper and 22 ordinary sleepers are laid, and for a rail length of 30 m. (98 ft. 5 in.) there are laid one double or broad sleeper and 45 ordinary sleepers. The distance of sleepers from centre to centre amounts in the former case to 650 mm. (2 ft. 1 5/8 in.) and in the latter 655 mm. (2 ft. 1 13/16 in.). The distance is somewhat smaller at the joint, being for 15-m. rails, 547 mm. (1 ft. 9 9/16 in.) for the first sleeper and with 30-m. rails 548 and 570 mm. (1 ft. 9 9/32 in. and 1 ft. 10 7/16 in.) for the first two sleepers.

Both types of sleeper are equipped, for the purpose of fastening the rails, with rib-plates which in the case of wooden sleepers are fastened by four coach-screws, and in the case of the steel sleepers, are welded round the edge. The foot of the rail is positioned between the two ribs which are rolled on to this soleplate. These ribs are milled out at

the centre in the form of an arc to take the rail fastening bolt. The clip fits over the rib and when the bolt is tightened joins rail and rib-plate firmly together. In order to allow for rolling inequalities and other lack of precision which must always be reckoned with in rolled sections, a poplar wood pad is placed between the rail and plate. These wooden pads, on account of the increased frictional resistance, decrease longitudinal displacement of the rail and also tend to reduce noise.

It is probable that this track will meet all requirements for years to come, and that its life will be considerably increased on account of the design and arrangement of its component parts.

The gauge is now only increased on curves of less than 300 m. (15 chains) radius, this being done by suitably boring the wooden sleepers, and by suitable welding of the rib-plates.

For this limitation of gauge widening, technical and economic considerations have been the governing factors. An undoubted disadvantage of increasing the gauge is that the vehicles are not firmly guided. This makes itself noticed, when long straight tracks are being covered, by the rolling of vehicles, particularly at the end of the train, for the flanges have even on straight track a play of a minimum of 10 mm. (13/32 inch) to a maximum of 25 mm. (1 inch). On curves, however, the increase in gauge assists the so-called « spear flight movement » of the vehicles, this means the running of the leading wheel against the outer rail which results in heavy wear on the rail and wheel.

From an economic point of view, by limiting the practice of widening the gauge not inconsiderable advantages

accrue. The use of special fastenings for track with an increased gauge has become unnecessary. Practically all wooden sleepers can be bored in the same manner before being impregnated at the impregnation works. The laying of the track is therefore made simpler.

Respecting rail joint gaps, the use of long rails has in no way given difficulty; the gaps specified for rails of 30-m. length are only a little larger than those for rails of 15 m. Thus the gaps based on air temperatures from plus 20° C. to plus 5° C. (+ 68° F. to + 41° F.) are 3 mm. (1/8 inch) for the 15-m. rails and 5 mm. (3/16 inch) for the 30-m. rails.

The rail gaps are calculated on the assumption that the rails, being firmly fixed to the sleepers, do not undergo any appreciable variations of length through difference of temperature, on account of the considerable resistance of the ballast, but rather that the stresses are taken up by the rails.

Ballast should transfer the pressure set up by the loads on the transverse sleeper as regularly and elastically as possible on to the formation. It should in addition prevent any sideways movement of the sleepers and so that the sleepers always remain dry, should lead away any water containing sediment. The ballast must therefore be open to allow water to drain away quickly and must be able to resist as permanently as possible running loads as well as the blows from the tamping tools.

For this reason only absolutely perfect chips of hard stone are used which are weather proof and do not reduce in volume, which have sufficient shock resisting qualities and hard edges and which can offer sufficient resistance with considerable elasticity. The chips must

be as cubically formed as possible with sharp edges. Their size should as a rule not be less than 3 cm. (1/8 inch) or more than 6 cm. (1/4 inch).

On account of the considerable importance which the provision of a perfect broken stone ballast meeting all requirements has on the permanent way, and therefore also on the vehicles, the German Railways decided to arrange a ballast testing centre for the whole of their railways. This centre has to test the stone which is tendered to them, for its analysis, to supervise the breaking of the stone and the deliveries made and also thoroughly to inform outside departments regarding the requirements to which good broken stone must conform.

The ballast formation for wood and steel sleepers is the same. The ballast as measured from the top of the sleeper is 0.40 m. (16 inches) deep in the middle of a double track line, and increases with the angle of the formation of 1 : 25 so that in the middle of each track it is 0.47 m. (18 1/2 inches) deep. On single track it is 0.45 m. (17 3/4 inches) in the middle of the track. The distance from the middle of the track to the edge of the ballast is 1.60 m. (5 ft. 3 in.) and the angle of slope 1 to 1.25.

#### 4. — Number of men in track maintenance gangs.

The permanent way must be carefully attended to in every respect in order to prolong its life to the furthest extent by making the utmost use of the available material. This end can only be achieved by means of *systematic*, thorough and coordinated maintenance.

For this reason the maintenance gangs

no longer work in fixed unchangeable gang districts, but in places within the gang office districts where systematic maintenance work is to be carried out.

The gangs are collected together according to the extent of the work to be done. This method is in any event often rendered necessary by the increase of rail lengths, rail weights, etc., which necessitates a larger number of workmen. The gangs have a greater strength in good weather than in winter. On the average there are 7 200 gangs so that to each falls 18 km. (11.2 miles) of track to maintain, including approximately 11 km. (6.8 miles) of main track and 42 switches reckoned on a single switch basis. The length to be maintained by the individual gangs on lines carrying dense traffic is decreased somewhat, but in parts where the traffic is small, it is considerably larger and reaches in secondary lines with a small amount of traffic, to nearly 30 km. (18.6 miles).

Each gang on the average is composed of 20 workmen; on lines with dense traffic this number is increased to about 30, which number is correspondingly reduced in districts with a small amount of traffic. These are to a certain extent purely theoretical figures, and actually, the number of workmen is suited to the amount of work to be carried out, and to the requirements of traffic. The numbers in the gang are also varied by withdrawals for auxiliary work, increasing other gangs, and for special detachments. Each gang is in the charge of an inspector. In cases where gangs are concentrated, the senior inspector is placed in charge and the remainder undertake special duties within the scope of the work to be done.

### 3. — Estimation of the necessary labour.

In order to ascertain the number of workmen required, it is not generally the length of track to be maintained which is the deciding factor, since special rules and scales of renewal are specified for the track governed by its age, traffic load, local conditions, etc., but we now fix in advance by programme the extent of the work which actually has to be carried out in each year and decide the labour requirements accordingly. This makes it essential that the district offices estimate this work beforehand, and in doing this they must examine exactly which work must be done on the tracks which are to be relaid and maintained according to programme, and what materials and how many man-days are necessary.

The General Headquarters lay down generally, within the scope of the means at their disposal, for each division, and based on the estimate, those lengths of track which are to be relaid, regard being paid to its age and traffic load, and the materials and man-days which may be used for the purpose. They also lay down the materials and man-days which may be used for ordinary maintenance.

The decision as to which tracks are to be relaid is taken by the divisional permanent way superintendent of the division acting on the general instructions issued by Headquarters, because only the divisional permanent way superintendent, on account of his local knowledge of the condition of the track in his whole district, is in a position to decide which tracks require relaying most urgently. The periods of time for the systematic examination of the track,

are laid down for each individual track, so that by this means the extent of the work to be done is arrived at. The division of man-days among the district and local officers is arranged then by the divisional permanent way superintendents according to the work which has to be carried out from time to time, and having regard to the density of traffic and local conditions. The district office has to supervise the carrying out of the work, and to see that the expenditure of labour and materials is not exceeded. When allotting the man-days, provision is made for leave, paid public holidays, etc.

#### 6. — Permanent, temporary and auxiliary labour.

Track work is seasonal work which as a rule can only be carried out during the favourable season of the year. The number of workmen is therefore different in summer and winter.

We make the following distinctions :

a) Permanent men, who are employed throughout the whole year. Their number amounts to about 50 to 60 % of the total number necessary for the average work which has to be carried out during each year;

b) Temporary men, who are put on to increase the gangs during the favourable season of the year, who as a rule are not engaged more than six months in the year;

c) Auxiliary men, who are only taken on for the purpose of dealing with temporary occurrence of extra work, such as snow clearing, breakdown work, and who are not employed more than six weeks.

In this manner the best possible arranging of the number of workmen for the work to be carried out is effected.

#### 7. — Secondary work which is carried out by track maintenance men.

The gangs should be engaged during the favourable season of the year on relaying and the maintenance of tracks and ballast. Other work such as cleaning out ditches, drainage work, fire protection belts, cutting of hedges, repairing of fences, snow drift shields, etc., should only be performed by the gangs as far as is possible during the unfavourable season of the year, so that the permanent men may be employed. Nevertheless the principles must be maintained that track maintenance does not suffer on account of such secondary work.

All other work is as a rule given out to contractors.

#### 8. — Systematic track maintenance.

The tracks are systematically maintained, that is to say, each portion of track is *thoroughly* covered at regular intervals varying according to the density of the traffic and with the age of the track, for instance, at intervals of 2, 3 or 4 years, and is at this time overhauled as to all its parts in such a manner that it can remain until the next inspection according to programme. One does not therefore wait until faults occur which are then remedied at the time, but as far as possible such faults are avoided in time. The earlier custom of working on the track at irregular intervals for the purpose of remedying faults which had already arisen, only had the effect of working disadvantageously on the whole make up of the track. The state

of the track became rougher rather than smoother. The result was increased wear of the various components of the permanent way, which necessitated their premature renewal. Systematic track maintenance obviously eradicates not only the results of track faults but also the trouble of them.

Maintenance of track according to programme is the most important duty of the permanent gangs of each gang office. It must not under any circumstances suffer owing to the carrying out of important renewals of track and ballast. For this latter work special gangs are therefore used in many instances, so called flying gangs as described above, or the work is undertaken by contractors.

#### 9. — Technical regulations for dealing with the materials and for the laying of track including the work connected therewith.

Steel permanent way materials are obtained from the manufacturing firms in a finished condition and are despatched to the place where they are to be used, in as far as they consist of heavy materials, in most cases direct, otherwise they pass through a main store for permanent way materials. They are tested with go and no-go gauges for the correctness of the specified measurements and for the permissible tolerances.

The wooden sleepers are delivered in a raw condition to the impregnation depots, and after being dried are then planed and bored; after that, they are impregnated with tar and fitted with the rib plates which are screwed on, immediately after impregnation, by four coachscrews. The sleepers then go di-

rect to the place where they are to be used.

If the method of carrying out the work does not make it otherwise necessary — (such as laying with track laying appliances) — the rails are distributed over the place where they are to be used so that intermediate storage is avoided.

The sleepers are also distributed on the site if there are no special reasons against this or if the method of carrying out the work does not demand otherwise. When being unloaded, the sleepers have to be handled with care.

The small steel parts are protected against weather until they are fitted in the track and as far as is possible are stored under cover.

When track laying apparatus is used, the materials are taken to the stations which are to be used as depots so that the sections of track may be assembled.

After removal of the old track, the ballast according to its condition is either cleaned or renewed, and relaid according to regulations. When cleaning the ballast the dirty or muddy ballast is removed from the track, forked over or sieved and again returned. The fresh ballast, contrary to previous custom, which allowed the ballast to settle down under the weight of passing traffic, has been recently artificially compressed with special ballast rollers or by hand tamping.

When track on wooden sleepers is being laid the sleepers are first laid out at the specified distances from each other by means of a distance gauge and then the pads of poplar wood are laid on the soleplates. Then the rails are put in and the sleepers are moved into their final position which is marked on both rails. After the fishing surfaces between

the rails and fishplates have been well cleaned and oiled, the fishplates are at first loosely screwed on, then the proper expansion pieces are put in according to the atmospheric temperature at the time. The correct position of the joints is tested by means of the rail square and the gauge of the track checked. The rail fastenings are now fitted and the nuts first screwed up loosely, the sleepers are tamped, and finally all screws are tightened up after the track has been correctly lined up.

When laying track on steel sleepers the ballast box method already described is principally used; otherwise the process is the same as in the case of wooden sleepers.

The methods of assembling the track at the side and laying it in sections, or of putting the new rails at first on the old sleepers and subsequently substituting new sleepers, may only be used exceptionally when intervals between trains do not allow otherwise.

Trains in public service are not allowed to travel over a track, which has not been sufficiently tamped and lined up, and the first public train which travels over the finished track must not exceed a speed of 30 km. (18.6 miles) per hour.

The track is lined up in accordance with the line and level pegs, which indicate the position of the centre of the track and the position of the top of rail level. The pegs on the straight are placed at intervals of 100 m. (328 feet); in level curves up to 500 m. (25 chains) radius, at intervals of 50 m. (164 feet) and in curves of less than 500 m. (25 chains) radius at intervals of 25 m. (82 feet), at the beginning and end of the curve as well as at the beginning and end of the

transition curves at points where the gradient changes, and at the beginning and end of the rounding off of changes of gradient.

The track is first roughly lined up; first the joints of the one track, then the joints of the other, and finally the middle of the rails are brought to their correct height by means of jacks and water levels.

After the track has been lined up, the sleepers are immediately well and regularly tamped, that is by hand tamping, as opposed to the already described machine tamping from both sides. For this purpose tamping sections are formed each with four men. At first just sufficient ballast is put between the sleepers so that tamping is not made difficult. The middle of the sleepers is not tamped but is just supported sufficiently with ballast that the tamped parts cannot move. By this means the riding of sleepers on their beds is avoided.

When the track has been completely tamped it is finally well lined up by means of lining bars during which process the track must not be lifted.

After tamping and lining up the rail fastenings are tightened up and are then coated with a tar preparation for protection against rust.

When ballast boxes are used for laying permanent way on steel sleepers, tamping the finished track before being used for traffic is not necessary. The position of the track must nevertheless be examined some time after completion of the work. Sleepers not properly supported by the ballast must then be tamped, errors in the height and position of the track must be corrected and the screws and nuts tightened up.

When renewing or improving ballast without interrupting the traffic the ballast is first removed to the level of the underside of the sleeper; the ballast is then taken out under two neighbouring sleepers down to the top of the formation and each sleeper is supported by means of two wooden blocks about 40 cm. (16 inches) long — sections of old longitudinal timbers are best. Each rail must be supported at the same time at the spot where the original sleepers were so that the track does not lie on one side. In order to give the rails a firm bearing when supporting traffic, two keys are driven in between the rails and wooden blocks. The ballast is now removed from under the sleepers between the wooden blocks, down to the formation, and is replaced with new or cleaned material. In this process the ballast which can be used again which is withdrawn from under the three sleepers in the direction of the work which is already being prepared for taking the wooden blocks, is used as a lower layer for the first sleepers. After the sleeper is tamped the two blocks used for the first sleepers are built into the third and then the process is repeated.

Broad sleepers are specially supported by blocks in the middle as well as the ends.

Trains must travel over the track, on which work is being done, at slow speeds, and at night the wooden blocks must be removed. With this process when work is being carried out on the track at several points at the same time, this may only be done at intervals of at least seven sleepers.

At the same time as the ballast is renewed, improvements to the formation are carried out. A good drainage and

therefore a dry formation is at first aimed at. Where this is not obtainable by the usual means, special measures are adopted. In soft subsoils this is done for instance by the construction of a porous layer (sand or fine cinders). In the cases of damp subsoils, rubble drains are provided. In cases where the soft subsoil swells up, and a good drainage is not obtainable by means of rubble drains, a non-porous layer of asphalt of ample strength has recently been constructed over the whole width of the top of the formation.

The growth of weeds on the ground work is prevented by spraying with sodium chlorate, using tank wagon trains. In amplification it should be pointed out that the most suitable time for spraying is the early part of the year when the ballast is still damp or on damp misty days. Most effective is spraying immediately after rain. On the other hand, spraying should not be carried out during heavy continuous rain. The tank wagon trains travel at 18 km. (11.2 miles) per hour. Each tank wagon train is usually made up of the locomotive, a living car for the man in charge of the train and the three workmen who are necessary for its service, and eight or twelve old tenders each of 12 to 20 m<sup>3</sup> (15.7 to 26 cubic yards) capacity with a total capacity of 160 m<sup>3</sup> (209 cubic yards). For destroying ordinary grass, spraying with a 2 % solution to a depth of 1 mm. (3/64 inch) is sufficient so that 2 kgr. (4.4 lb.) of sodium chlorate in 100 litres (22 British gallons) of water are sufficient for spraying 100 m<sup>2</sup> (120 sq. yards) of track. In parts where it is moderately or densely overgrown, the amounts are increased. With an average spraying width of 4.50 m.

(14 ft. 9 in.) the following are the approximate requirements :

For 1 km. of track with little growth, 4.50 m<sup>3</sup> (1 600 British gallons per mile) of solution;

For 1 km. of track with average growth, 6.75 m<sup>3</sup> (2 400 British gallons per mile) of solution;

For 1 km. of track with dense growth, 9.00 m<sup>3</sup> (3 200 British gallons per mile) of solution.

#### 10. — Piece work.

All track maintenance work is carried out on a piece work basis by the railway employees where it is possible and economical. The jobs are measured according to time. Piece time is the time which a workman of average capacity needs to carry out the given work in a proper manner and at a normal rate. Piece times are ascertained for each different job and as regards the indirect work connected with the main job this is either included or excluded. The times are laid down by the head of the district office after approval of a member appointed by the local labour representative. If agreement is not reached the railway division makes a decision.

Piece work is given either to individual workmen (individual piece work) or to gangs (gang piece work). The workmen receive an order sheet on which the work to be done and the agreed piece time are shown. If jobs occur during the carrying out of the work which are not provided for on the order sheet, a supplementary arrangement is made.

Premium rates are not given.

Piece work is inspected after completion of the work. If difference of opinion

arises about complaints, the head of the district office decides after consultation with the representative of the piece workers union. Piece workers are obliged to attend to complaints which occur after inspection as a result of operating causes or faulty work during the week following the inspection without special remuneration and against the piece time laid down. The work is not considered as finally passed until faults are remedied. By this means the assurance is provided that the quality of the work does not suffer on account of the endeavour to complete the work as quickly as possible and thereby attain as high a wage as possible.

For the maintenance of 1 km. of single track, reckoned per year and varying according to the age and traffic conditions of the track and calculated on the total length of all track which has to be maintained, 130 man-days are required on the average, or expressed in money, about 930 Rm. (208 man-days and 1 488 Rm. per mile). The cost of the complete renewal of track and ballast with new materials is not included in these figures.

#### 11. — Working hours.

The regular working time amounts generally to 8 hours per day and 48 hours per week in both cases, breaks being excepted. Men engaged on actual track maintenance must do up to 6 hours overtime per week from the 1st March to the 31st October, so that during this period 9 hours are worked daily excluding breaks. In urgent cases over 54 hours per week are worked. This overtime is paid for at an increased wage rate. The hours of working are laid down by the wages agreement made by the Reichsbahn.

## 12. — The commencement and finish of the work.

The work begins and finishes at the specified working areas. For the gangs stretches of track are fixed, the total extent of which reckoned on length amounts to not more than 5 km. (3.1 miles), and 2 km. (1.24 mile) to either side at right angles to the line and which serve as working areas. When deciding these areas only economy and the requirements of the work are considered. Generally speaking, the areas are therefore made in the place where the work is mostly done, that is to say, during the greater part of the year (see Systematic track maintenance).

The possibility of paying attention to the district where the majority of workers live is not prevented by this principle either as far as the position or as regards the dimensions of the area, if such consideration is warranted or advantageous on account of labour requirements. Such a case is shown for instance when an area has been defined solely from economic reasons, but the necessary workmen are difficult or impossible to obtain owing to their living an excessive distance from their work, or if the majority of the workmen have to come such a long distance that a considerable decrease in their capacity for work would result.

The areas are changed should it happen that during the greater part of the year work has to be carried out most frequently in a district different from the one at first anticipated when deciding the area. The areas may only be changed for a short period if this is done out of consideration for the workmen.

If the workmen have to travel outside

the limits of the area their standard hours are reduced by 10 minutes for the journey each way for each complete kilometre at which the new site of operations is distant from the end of the area. Instead of a reduction of time one sixth of the hourly wage may be arranged as extra remuneration for each complete kilometre (0.62 mile). The reduction of 10 minutes to and from work also applies in cases where the workman in order to reach the place where his work is situated does not have to pass through his regular district. If the place where the work is situated is reached by rail conveyance (train, rail car, etc.) the working hours are reduced by the actual travelling time from the end of the area including any time for walking that may be necessary (10 minutes per km. = 16 minutes per mile).

If work is carried out outside the areas at higher rates of pay, the time of travelling is not taken into account.

## 13. — Conveyance of workmen on the line.

For the transport of workmen to and from the site of operations, trolleys are used especially on tracks where traffic is not dense, where, as a result of maintenance, areas are very long and the possibility of using trains is small.

These trolleys are mostly driven by hand by means of a lever or crank. They can carry 10 workmen of which 4 are needed for propelling the trolley. It is not considered advantageous to build larger and heavier trolleys since they would then be difficult to place on the track. In case of necessity two trolleys are preferable which must either be coupled or maintain a distance of 30 m. (33 yards) apart when travelling. Having

regard to the special purpose of these trolleys it is not, generally speaking, advisable to equip them with a power drive as they then become too expensive and therefore uneconomical. Only on lines with steep gradients does the question of equipping the trolleys with motors arise so that the workmen shall not become too fatigued.

Trolleys driven by hand must be equipped with powerful brakes. During the journey they must be accompanied by a traffic official who is empowered to drive the trolley. The driver must carry a time table for the line, a watch, and a means for signalling.

When travelling on the open track enough men must travel with the trolley to be able to lift it off the track quickly. The speed in the case of the trolley must not exceed 30 km. (18.6 miles) per hour and with other small trolleys 15 km. (9.3 miles) per hour. In the dark or during low visibility, trolleys may only be used in urgent cases; they must then bear special light signals.

If power rail cars with motor drive are used for the transport of workmen the following special regulations apply:

For each car a properly instructed driver must be present who must always carry his driving papers with him. He must be a traffic man. The car may follow a train immediately when it is necessary. This is nevertheless forbidden when it is dark and in weather of low visibility, as well as on tracks where visibility is bad and in sections where tunnels occur. Before open level crossings and crossings where the barriers are not locked, a warning signal must be given, and the car must be driven very carefully so that it can be stopped immediately an obstacle is seen. The main signals are generally not used for such

cars. The passing of home and block signals is arranged by the assistant station master by means of an audible and visible signal. These cars can travel on the open track at 25 km. (15.5 miles) per hour.

All journeys with these cars, both those driven by hand and those driven by power, can only be made with the approval of the signal boxes concerned and under advice to the various block sections.

Mechanics, telegraphmen, signalmen, etc., are not provided with means for transport.

Moreover, they do not receive any extra remuneration for the use of their own bicycles, etc. In cases of necessity the usual trolley available is used for their transport.

#### 14. — Working up of track materials in order to increase their life.

Each track is subject to continuous variations in its condition, which are caused partly by the continual effects of traffic passing over it, and partly by the natural wear of the materials. If the resultant troubles are recognised and removed sufficiently early, the results are less harmful and the life of the material increased.

For this reason at each systematic examination and thorough overhaul of the track, all worn fastenings must be removed and replaced. We use for this purpose renovated fastenings to which attention has been paid not only to obtaining the original dimensions by die pressing, etc., but also to the wear of the parts which come into contact with them (rails, soleplates) so that proper tightening of the permanent way parts can again be obtained. This

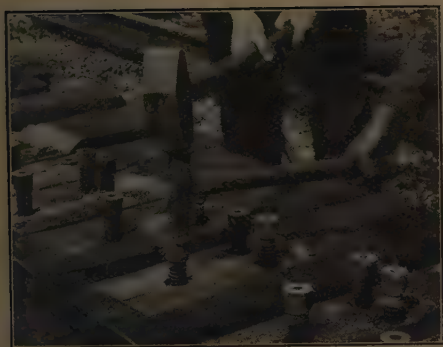


Fig. 33a. — Plugging wooden sleepers with ribbed plugs.

renovation applies chiefly to the fish-plates, the hooked soleplates of the old type standard track and the clips, etc. Also steel sleepers which have been cracked or broken at the rail seat are made serviceable again in that the ends of two sleepers are cut off and, by means of welding together their middle portions which are not worn so much, bending over the ends and punching the holes, a new serviceable sleeper is made.

Wooden sleepers made of pine, the coachscrew holes of which have become large, are plugged for the purpose of increasing their life, and then provide a sufficiently firm hold for the coachscrews. For this purpose a ribbed plug is now exclusively used which is made of red or white beech wood, and impregnated with tar. The plug is ribbed on the outside and the lower part is split into four. The sleeper holes having been previously bored out, the plugs are driven into the sleepers (see figure 33a). Figure 33b shows a sleeper after it has been planed and plugged.

In addition to the ribbed plugs, so called

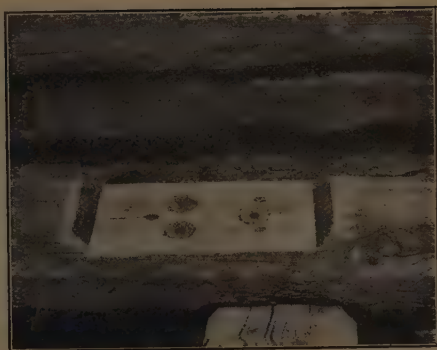


Fig. 33b. — Planed and plugged wooden sleepers.

plain plugs are used. These are plugs considerably lighter than the ribbed and have to be driven in by special tools. For these it is not necessary to bore out the coachscrew holes in the sleeper.

The plain plug is generally used where the coachscrew hole has just been widened through damage to the fibre, and the coachscrew does not hold properly. It can be driven into a sleeper lying in the track without any preparation.

The ribbed plug on the other hand is used in cases where the coachscrew holes show signs of rot. For this plug the hole is bored out beforehand and by this the rotten fibre is removed. This work can also be carried out in the track after the sole plates have been removed.

All switches removed from the track are handed over to Reichsbahn switch depots where the materials are examined for their availability for further service. Out of the materials so available and after renovation including provision of new materials, switches are made for further use on less important track.

15. — List of the various items of maintenance work carried out and the time taken for them.

Graphical records of the permanent way of the main lines are kept as shown in Appendix 7, which are based on a period of 25 years and which give a continual survey as to which types of permanent way sleepers and ballast are lying in the main lines and when they were renewed. The record shows in addition the gradients of the track and a diagram of the curves with special remarks regarding the individual curves.

In addition a graphical record of the condition of maintenance of the main line permanent way is kept as shown in Appendix 8 which deals with a period of 4 years shows the work which has been carried out in each month of the year in renewing and maintaining the track and ballast, and the man-days which have been used for this. In addition the sections which are to come up for systematic examination in each year are specially recorded. The entries in the graphical records agree with the records kept by the gang foremen.

By means of these records the actual

expenditure reckoned in man-days for the various jobs is recorded as a whole. For this reason this figure forms a valuable basis for the following years' estimate, but it can nevertheless only be taken as an average figure as conditions at each site of operations vary considerably. For the exact estimation of the expenditure of time for a given job, as for instance is necessary for piece work arranging, all factors which come into consideration, such as the condition of the track, local conditions (high embankments, viaducts, etc.) density of traffic, etc., must be specially considered each on its own merits; for only then can the piece time be approximately correctly ascertained. For piece work arrangements therefore, the piece time must be refixed in each case, even if similar work has been already apparently done. The following times are standard. They can be less, given good work on the part of the workmen. An average traffic is assumed, that is to say, that 48 trains travel on the line on which the work is being carried out, and on the neighbouring line. For each train in addition to this figure, an increase of 1/200 is reckoned. For trains which travel slowly, double the time is reckoned.

a) *Handling of materials :*

1 ton of rails — loading . . . . .	2.00	hours
1 ton of rails — unloading . . . . .	0.85	—
Total . . . . .	2.85	hours
1 m <sup>3</sup> (1.0 cubic yard) of broken stone — loading . . . . .	0.80 (0.61)	hour
1 m <sup>3</sup> (1.0 cubic yard) of broken stone — unloading . . . . .	0.45 (0.34)	—
Total . . . . .	1.25 (0.95)	hours

1 m <sup>3</sup> (1 cubic yard) of gravel — loading . . . . .	0.60 (0.46) hour
1 m <sup>3</sup> (1 cubic yard) of gravel — unloading . . . . .	0.40 (0.31) —
Total . . . . .	1.00 (0.77) hour

b) *Actual maintenance work:*

1 metre (1 yard) rail (49 kgr. per m.=98.8 lb. per yard) renewing . . . . .	0.64 (0.585) hour
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Tamping a wooden sleeper :

in gravel ballast, including laying, lifting 5 cm. (2 inches), lining up and filling in . . . . .	0.81	—
in chip ballast, otherwise as above . . . . .	0.87	—
Tamping a steel sleeper in stone ballast, otherwise as above. . . . .	0.99	—

Adjusting the track for line and level is carried out during tamping. The time for this is included in the above figures.

Renewal of a sleeper in the track on an open line :

Wooden sleeper in gravel ballast including tamping . . . . .	1.50	—
Wooden sleeper in broken stone ballast, as above . . . . .	1.70	—
Steel sleeper in broken stone ballast, as above. . . . .	1.90	—
For renewal at stations, each, an increase of . . . . .	0.10	—

Renewal of 1 m<sup>3</sup> (of 1 cubic yard) of ballast :

Removal of old gravel ballast and correct relaying of new gravel including the first tamping and adjustment . . . . .	1.55 (1.18)	—
Removal of old gravel ballast and relaying new broken stone as above . . . . .	2.33 (1.78)	—
Removal of old broken stone ballast and relaying new broken stone as above . . . . .	2.50 (1.91)	—

Expenditure for weed destruction per 1 metre (per 1 yard) of track is as follows :

Spraying with sodium chlorate over a width of 4.50 m. (14 ft. 9 in.) with the use of tank wagon . . . . .	0.066 (0.06) Rm.=	0.08 (0.073) hour.
By hand for 4.50 m. width with dense growth . . . . .	0.20 (0.18) Rm.=	0.25 (0.23) hour.
With less dense growth . . . . .	0.15 (0.14) Rm.=	0.18 (0.165) hour.
Systematic maintenance of 1 metre (of 1 yard) of permanent way 2.3 to 2.7 hours. . . . .		(2.1 to 2.47)

In addition the age of the track affects this expenditure because the extent of the work to be carried out, especially the renewal of parts, increases with the age of the track.

Renewal of 1 metre (of 1 yard) of permanent way without renewal of ballast . . . . .	6.75 (6.17) hours
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## 16. — Training, education and instruction of employees.

The best permanent way would soon fail in service if it were not properly inspected and looked after. For this reason a thorough knowledge in respect of all questions and requirements dealing with permanent way matters is demanded from the managing and inspecting departments, and the staff controlled by them down to the track maintenance man himself must feel that their work is properly and technically correctly managed and supervised.

In the first place the idea that any unskilled workman can be effectively employed on the permanent way because it is a matter of purely mechanical work, must be opposed. Really perfect and economic track maintenance is only possible with intelligent and well trained men, but, of course, a certain number of untrained men can be used for ordinary jobs, giving assistance, etc. For this reason, when choosing workmen care must be taken that they are well suited both mentally and physically. It is generally possible to cover requirements in suitable permanent staff men from the temporary labour employed during the summer.

In addition to this, at the present moment the education committee is laying down principles for the training of unskilled gang workmen in which these points are paid attention to.

In view of the mechanisation of the work and other developments in the field of permanent way matters, higher qualifications than hitherto considered necessary will be required in the future respecting the preliminary training and education of the gang foremen. The extent of the preliminary training which

will be required and the means by which further training will be controlled is being examined at the moment.

At the moment it is required from an applicant for the position of gang foreman, that he shall have been employed for at least 2 1/2 years as a ganger on track maintenance and that he has certain ordinary knowledge.

For promotion to the position of gang foreman, a better training and education in permanent way matters is already assured. As beginners on constructional duties, usually only those who hold certificates of five 1/2-yearly terms of recognised technical schools are engaged, who have been employed for two years in a works, and who possess a certificate of having reached a certain position at school.

The apprenticeship or education of these applicants lasts for three years. After completion of their apprenticeship a report on their examination is submitted to the Chief Technical Secretary of the Railways.

Permanent way inspectors, for which position specially efficient gang foremen are chosen, receive special training for their posts. Opportunity is given to them to get to know thoroughly all the various jobs which come in the range of their duties. For this purpose they are trained and temporarily employed in the construction of permanent way, in the inspection of permanent way materials at the manufacturers' works, in the management and administration connected with permanent way materials, at the divisional offices and stores, at the impregnation and manufacture of wooden sleepers in the impregnation depots, etc.

For officials employed in the higher track maintenance service, a thorough

training in permanent way matters and materials is provided.

The gang foremen and the gang inspectors are employed permanently as officials and receive according to the salary-class to which they belong, a title describing their occupation; chief inspector, permanent way inspector, gang foreman, gang inspector, gang master. Men in preparatory training for the intermediate technical posts bear the title of technical assistant.

The continual education of the employees is assured by means of educational courses and lectures. Beginners are obliged to visit the beginners' classes arranged by the management. Apart from this, opportunity is given to a considerable extent to beginners to belong to

schools existing in various places. This latter arrangement is looked after by the officials themselves and supported by the management. In addition matters of education are so arranged that a special education superintendent is appointed for several divisions whose chief task lies in the education of officials. The education superintendent has special education cars at his disposal which deal with the various trades so that even the employees employed on the track are given an opportunity to increase their knowledge by means of exhibits in the cars and film lectures. The various trade institutes also advance the education of their members by means of lectures for which the management freely places suitable officials at their disposal.

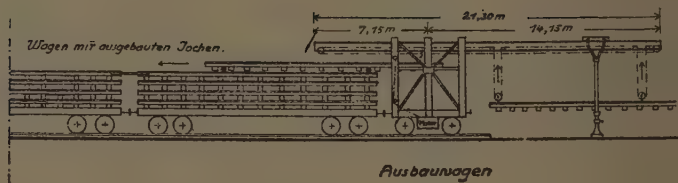
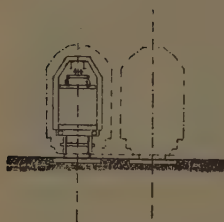
## APPENDIX I.

Schedule of the various tools and recent appliances being employed,  
giving the date of their introduction.

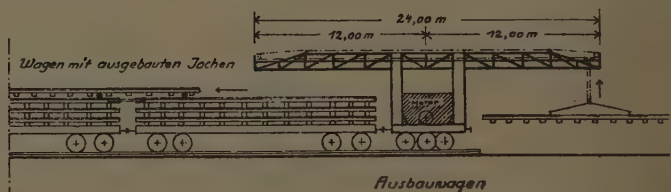
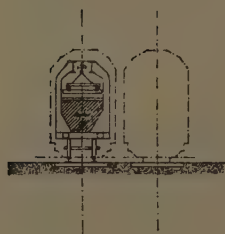
Item number.	Description of the various appliances.	Number of appliances in service.	Introdu- ced since :	Remarks.
1	Track tamping machines . . . . .	1 300	1921	Have been improv- ed in the mean- time.
2	Portable electrical generating sets with tools used therewith such as :	270	1925	
	a) Sleeper boring machines . . . . .	340	1925	
	b) Screw tightening and loosening machines.	480	1925	
	c) Rail saws . . . . .	60	1925	
	d) Track illumination apparatus (lamp)	280	1925	
3	Tracklayers . . . . .	20	1925	
4	Ballast rollers with power drive . . . .	35	1924	
5	Ballast boxes :			
	a) For track on steel sleepers . . . . .	5 800	1926	
	b) For switches on steel sleepers (sets) .	100	1929	
6	Rail loading apparatus . . . . .	365	1912	Since considerably improved.
7	Motor trolleys (2 and 3-seater) . . . . .	820	1925	
8	Motor inspection trolleys . . . . .	35	1927	
9	Heavy rail motor cars for inspection . . .	40	1927	
10	Self-discharging ballast wagons . . . . .	640	1926	
11	Tank wagon trains for chemical destruction of weeds on the track.	50	1926	



Tracklayer, Ho



Tracklayer, type Niederheim.—



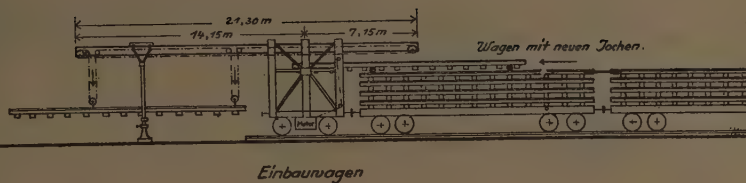
Works within the load

Transportation of the section

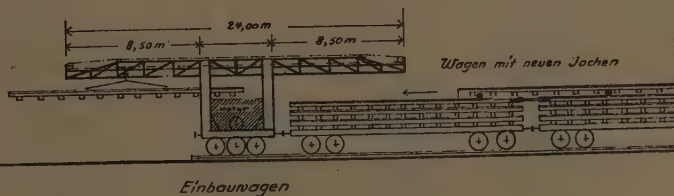
Assembly of the sections of track if materi

Explanation of German terms in diagrams: Ausbaumwagen = Track loading wagon, — Einbaumwagen =  
 Jochen = W.

(Frankfurt/Main).



A. G. (Niemag-Duisburg-Meiderich).



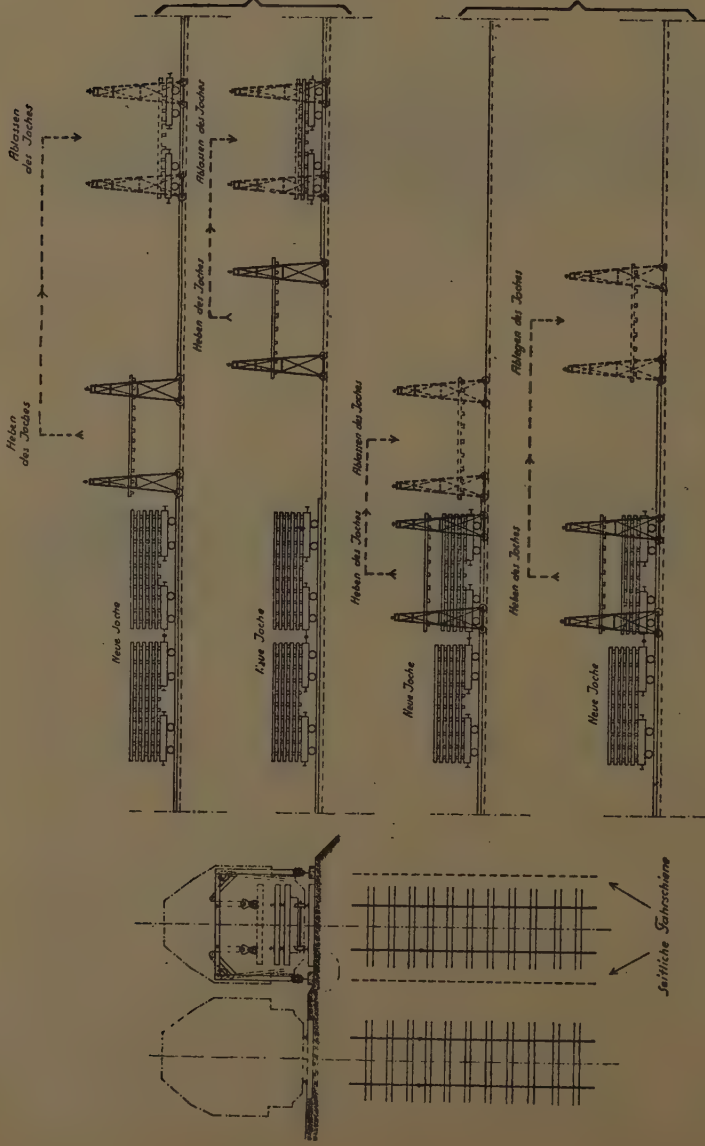
age : with two tracklayers.

by hand to the  
power on to the

laid ready. — Section length : 49 ft. 2 1/2 in.

laid ready wagon. — Wagen mit ausgebauten Jochen = Wagons with old sections. — Wagen mit neuen  
laid ready with new sections.

Track laying crane. — Neddermeyer (Halle-S.).



Removing old sections.

Works within the loading gauge : with rolling frame-cranes on outside guide rails.

The cranes are moved by hand.

Sections of any length dealt with.

Laying new sections.

Assembles sections of track, when materials are laid out.



When renewing ballast, the crane lifts and moves containers fitted to special narrow gauge trucks.

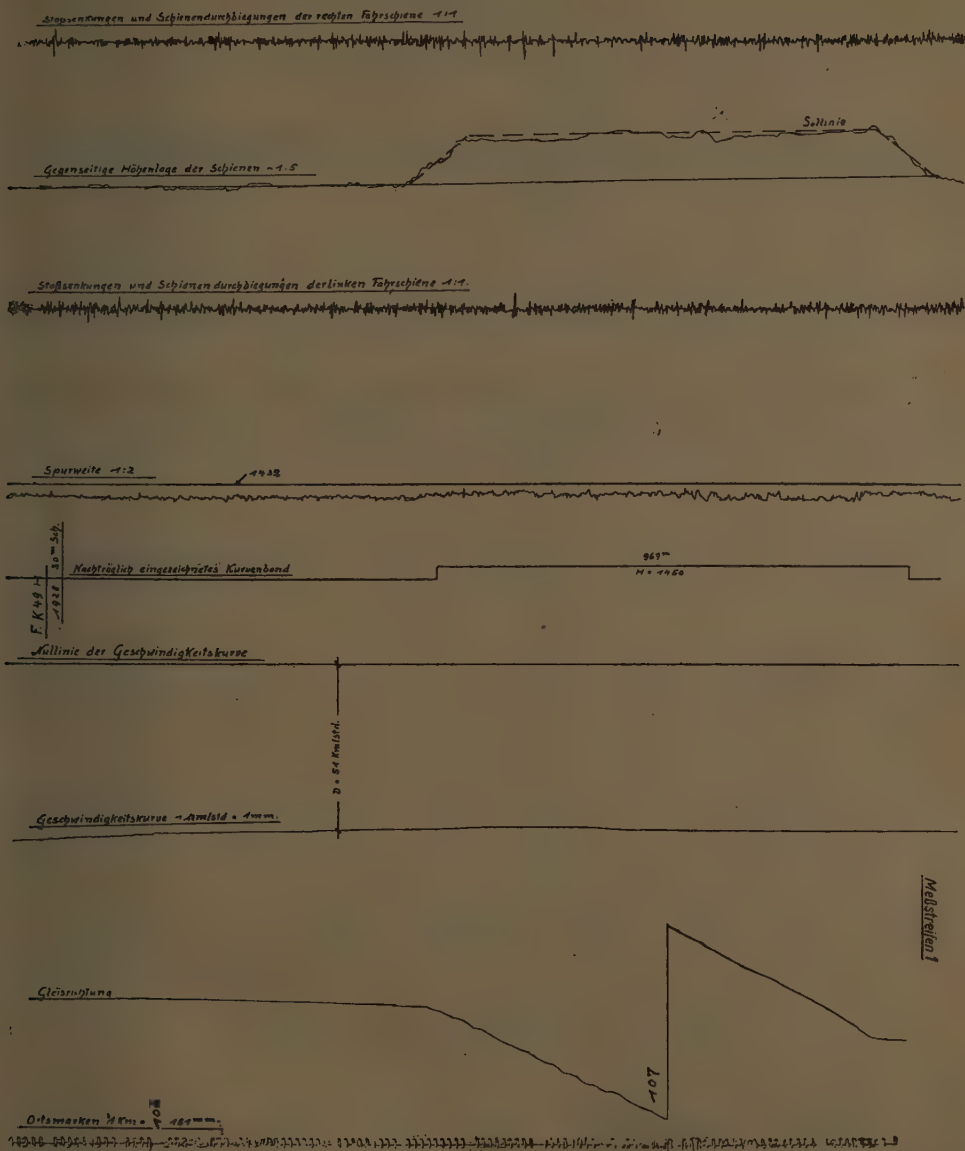
Leernwagen für ausgebaute Bettungsmassen.

Aufzugsvorrichtung



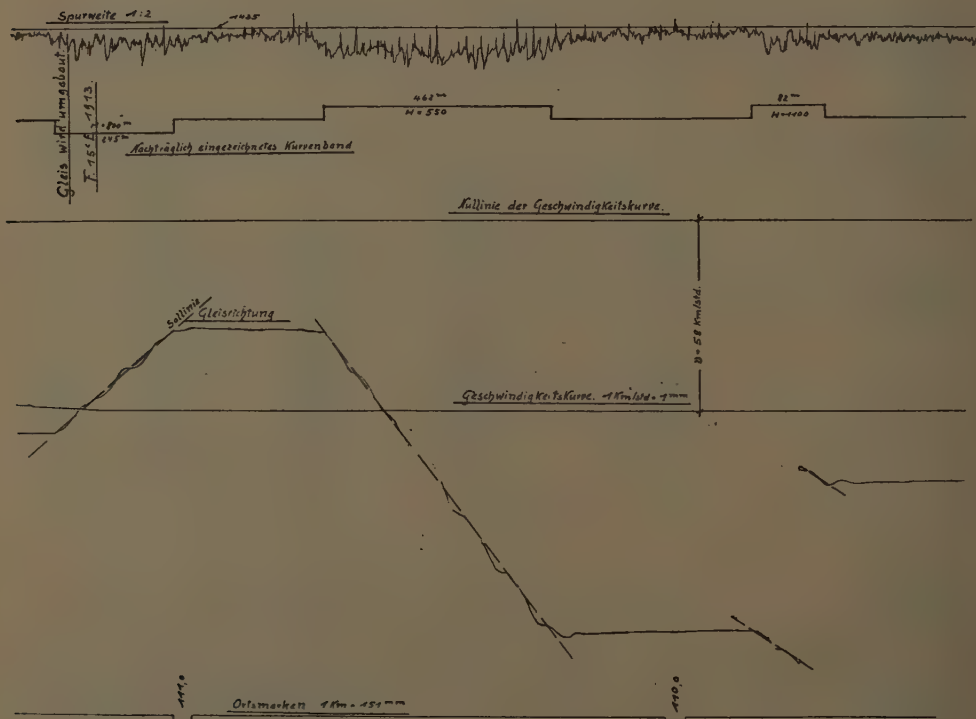
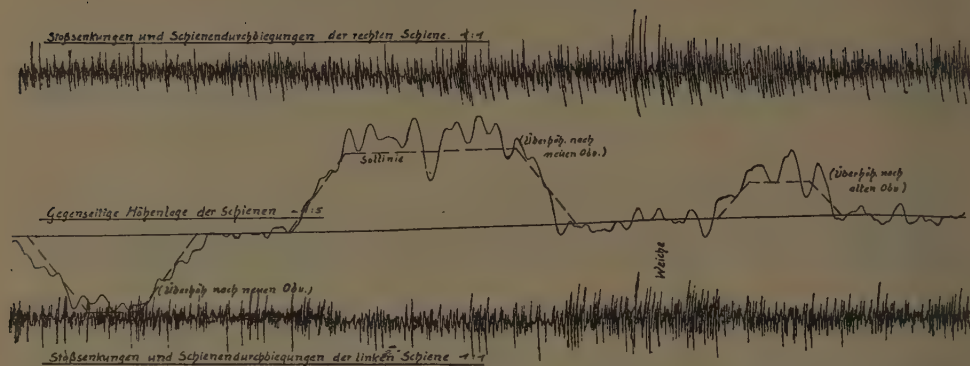
Explanation of German terms in diagram : Ablassen des Jochs = Lowering the section. — Aufzugsvorrichtung = Drawing gear. — Heben des Jochs = Lifting the section. — Leernwagen für ausgebaute Bettungsmassen = Empty wagons for old ballast. — Neue Jochs = New sections. — Seilliche Fahrschere = Side rails.

Track in good condition.



Explanation of German terms in Appendices 5 and 6: Gegenseitige Höhenlage der Schienen 1:5 = Relative height of the rails, 1:5. — Geschwindigkeitskurve 1 km/std = 1 mm = Speed graph — 1 km. per hour = 1 mm. — Gleisrichtung = Alignment of track. — Gleis wird umgebaut = Track is being relaid. — Nachträglich eingezeichnetes Kurvenband = Curve indication drawn in subsequently. — Nullinie der Geschwindigkeitskurve = Zero line of the speed graph. — Spurweite 1:2 = Gauge 1:2. — Ortsmarken 1 km = 151 mm. = Distance 1 km = 151 mm. — Sollinie = Normal line. — Stößenungen und Schienendurchbiegungen der rechten (der linken) Fahrschiene 1:1 = Joint shocks and rail deflections of the right-hand (left-hand) rail 1:1. — V = 51 km/std = Speed = 51 km. per hour. — (Ueberhö. nach alten Obv.) = (Super-elevation old standard). — (Ueberhö. nach neuen Obv.) = Super elevation new standard. — Weiche = Switch.

Track in bad condition.



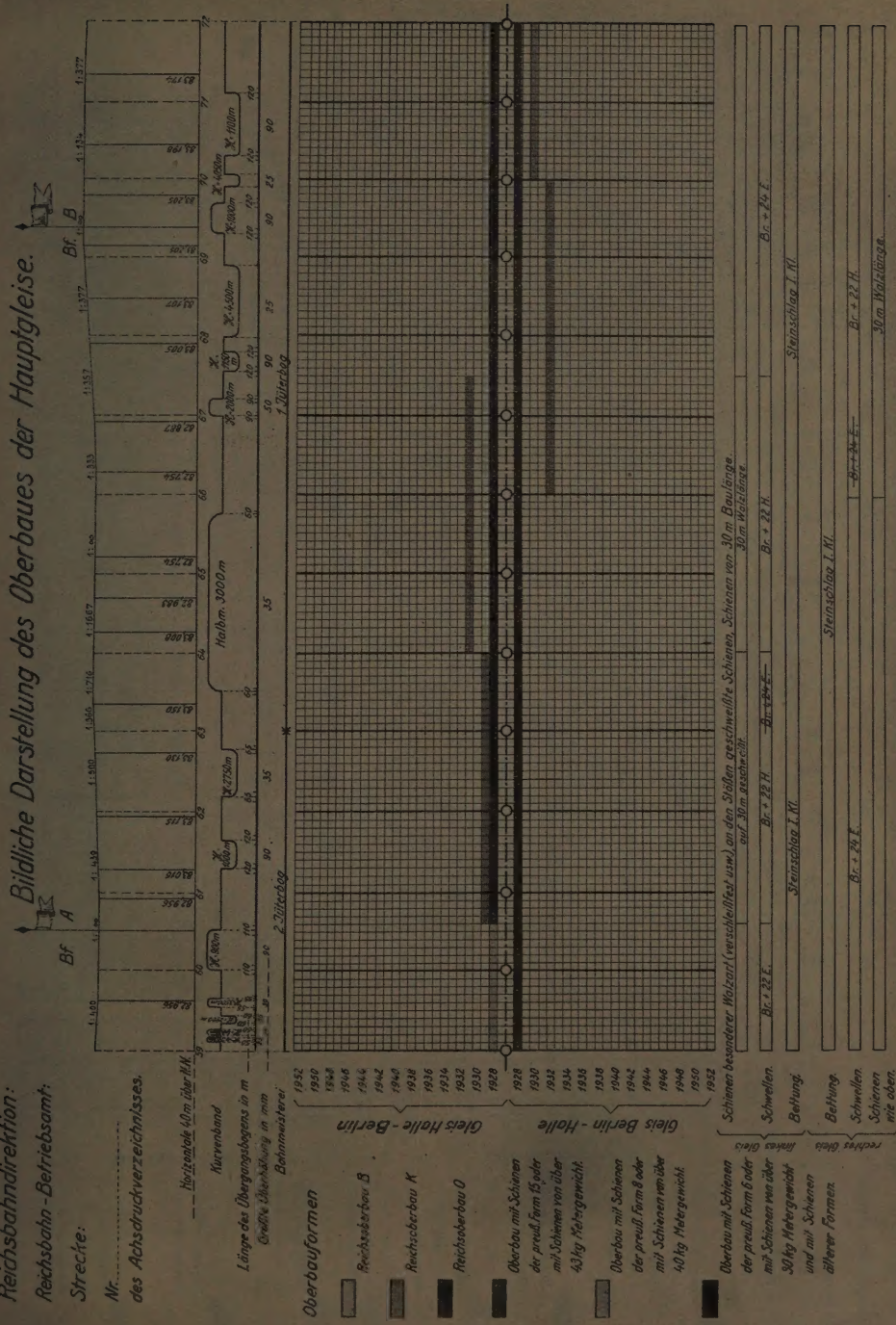
Reichsbahndirektion:

Reichsbahn - Betriebsamt:

Strecke:

Nr.

des Achsdruckverzeichnisses.



Graphical diagram of the permanent way of the main lines.

Reichsbahndirektion:

*Reichsbahn - Betriebsamt:*

Strecke:

Mr.

des Achsdruckverzeichnisses.

Horizontale über M.N.  
Kartenband.  
Bahameistererei.  
Oberbauform.  
Einbaujahr - Alter.  
Bettung - Gesteinsart.

Gleise, die zur plan-  
mäßigen Durchar-  
beitung für das folgen-  
de Jahr in Aussicht  
genommen sind

Planmäßig durchge-  
arbeitete Gleise.

*Vollständige Gleis-  
erneuerung mit  
Neustoffen.*

*Bettungsverbesserung.*

Schwellenausweise.  
kung im Zusammenh.  
de.

*Schienenumschaltung  
im Zusammenhang:*

Abwändige Gleisen.  
Verwendung mit Allstoffen  
unter heiliger Verwen-  
dung von Heilstoffen.

Gleis Halle - Berlin.

Ufers Berlin-Halle.

Bildliche Darstellung des Unterhaltungszustandes des Oberbaues der Hauptgleise.

